

# ANNUAL REPORT

2011



Ludwig Boltzmann Institute  
Archaeological Prospection and Virtual Archaeology

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# LBI ARCHPRO - OVERVIEW

## 1. GOALS

Considering the massive threat of destruction and deterioration of buried cultural heritage and the need for efficient and reliable identification, documentation and interpretation methods, large-scale application of non-invasive archaeological prospection methods comprise a great potential. They are the most appropriate solution in order to provide archaeologists and planning authorities with the necessary spatial information for the protection and possible investigation of such threatened heritage at the appropriate scales: the archaeological site as well as the surrounding archaeological landscape.

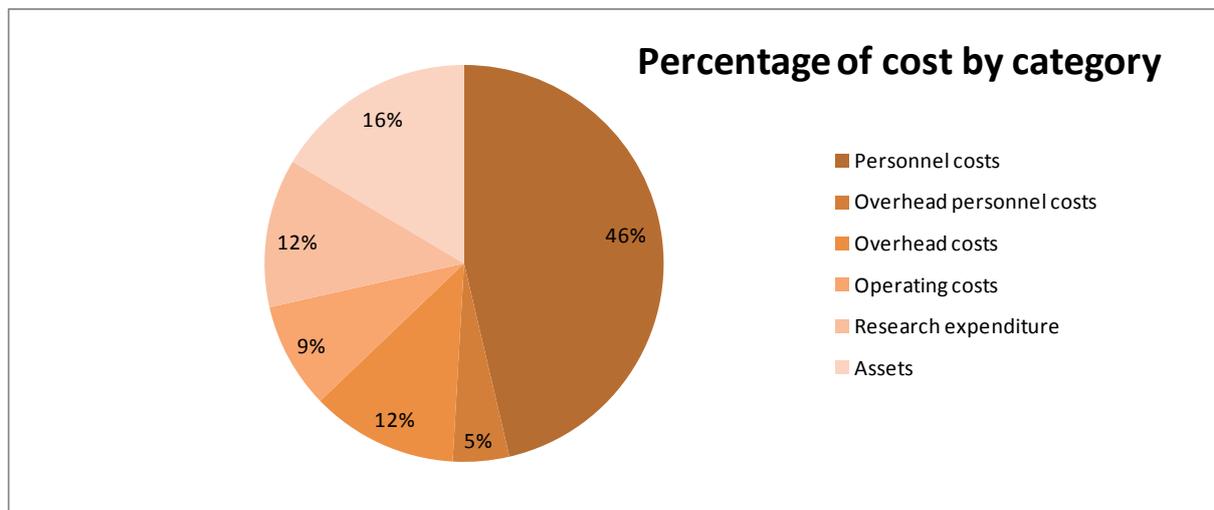
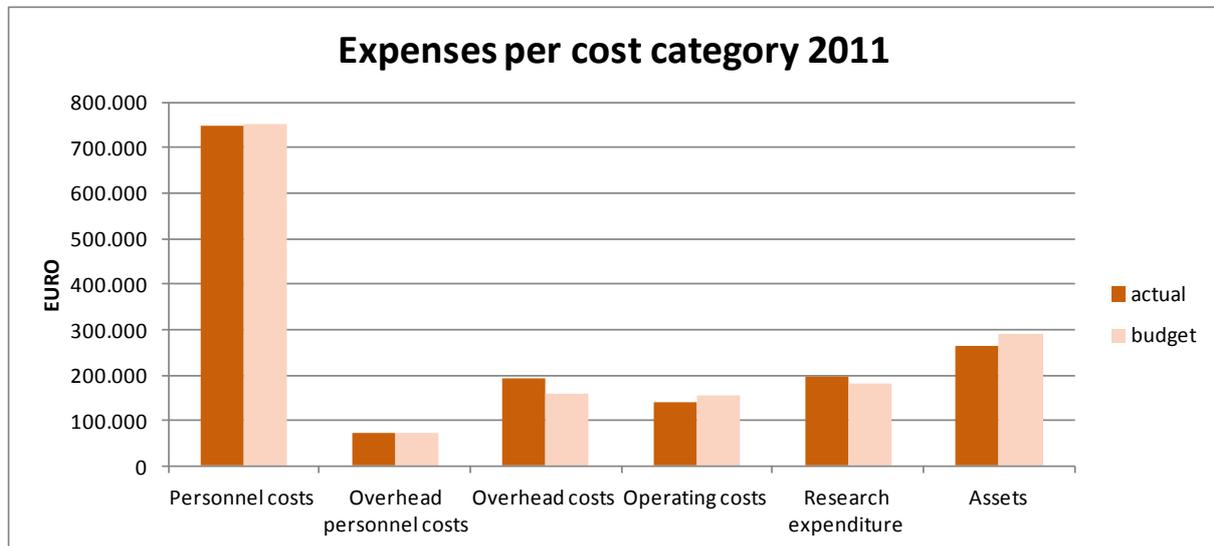
Considering the state-of-the-art and the future demands for non-invasive professional archaeological prospection a consortium of European research institutes, heritage boards and public bodies supported by the Ludwig Boltzmann Society (<http://www.lbg.ac.at>) established in 2010 the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro). The LBI ArchPro (<http://archpro.lbg.ac.at>) is an innovative research centre for the development and application of advanced non-destructive prospection methods. It combines advanced remote sensing methods, high resolution near surface geophysics, sophisticated computer science, geomatics and archaeology. It is dedicated to the development of new and highly efficient technologies for non-invasive data capturing, data processing, virtual reality visualization and the advancement of theory and methodology. An important aim is the publication and dissemination of new developments and results of the conducted research and of exemplary international case studies in professional circles as well as to the general public.

Even though the Valetta convention (Malta treaty) has not been ratified by all member states of the LBI ArchPro consortium, it is regarded by the consortium as the major basis and guideline for the future development of archaeological research and the LBI ArchPro research programme.

## 2. FINANCIAL OVERVIEW

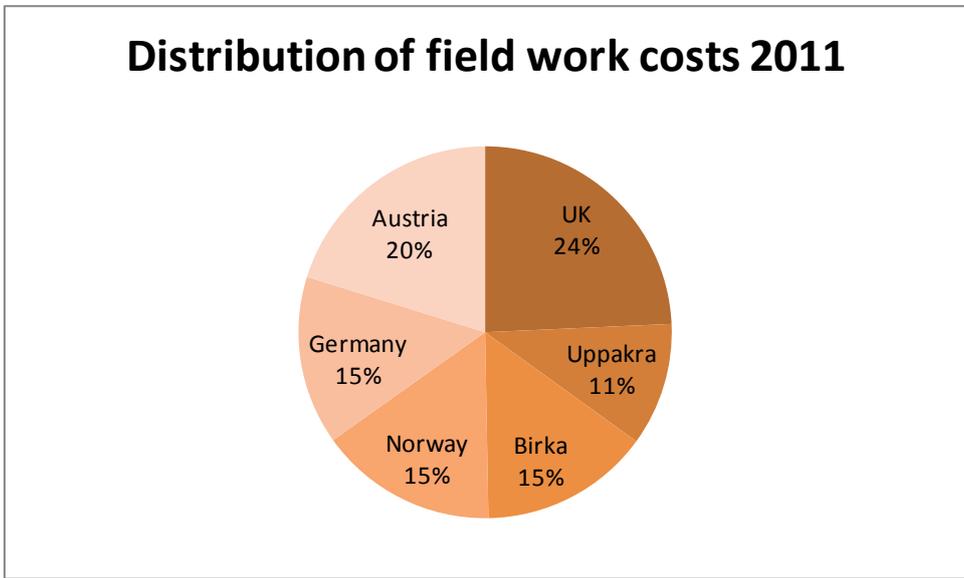
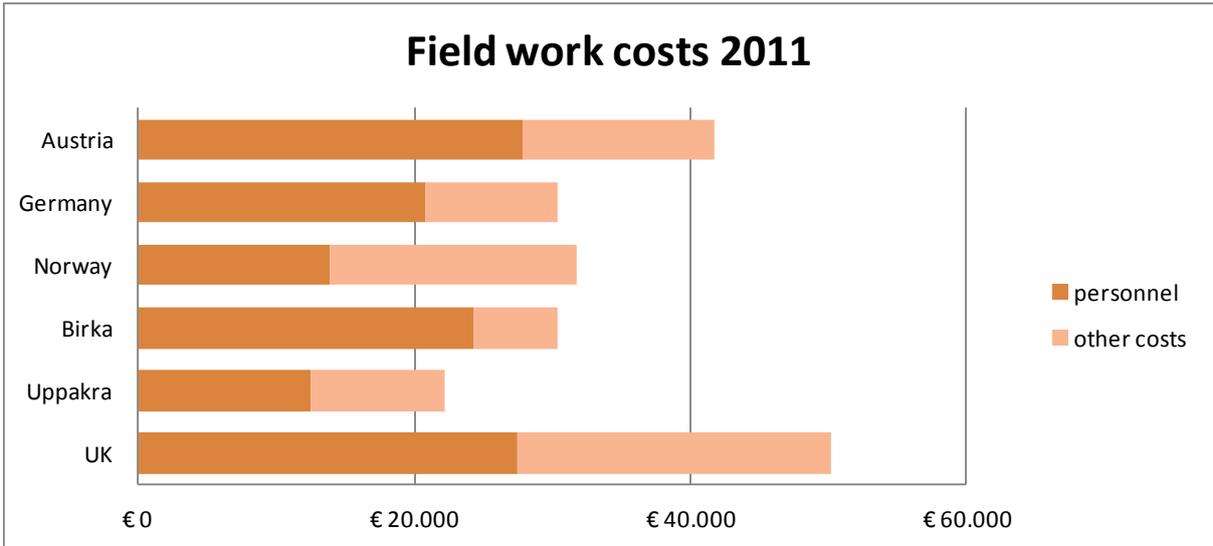
### BUDGET 2011

The final LBI ArchPro budget for 2011 (it was reviewed mid 2011) amounted to € 1.6 million and was fully exhausted.



Nearly 75% of the LBI ArchPro budget was used for scientific personnel, equipment (largely scientific) and research expenditure, while overhead costs remained under 20% of the total budget.

The overview of costs related to fieldwork carried out for the case studies in 2011 shown below does not take into account work overtime in the field, preparation time or post processing. Stonehenge again was by far the most costly case study, considering that in Sweden two fieldwork surveys were carried out at different sites. Overall there was an increase in fieldwork related costs compared to 2010.



**THIRD PARTY FUNDING**

On top of the fixed annual budget, the institute aims to obtain additional third party funding on a project base, in order to:

- address complementary research areas
- investigate additional case study areas
- employ additional researchers, particularly young scientists (PhD)
- obtain additional resources for research assets and research effort

**In 2011 following proposals for funding of research projects were submitted:**

**FP7-People**

A proposal for a FP7-People Initial Training Network (call FP7-PEOPLE-2011-ITN) was submitted in January 2011. The requested funding for the institute was around €650,000 over three years. The proposal did not pass the necessary threshold, but will be under circumstances re-submitted.

## **FP7-ENV**

The institute was involved in the submission of a proposal to the FP7-ENV-2012 Call - Development of advanced technologies and tools for mapping, diagnosing, excavating, and securing underwater and coastal archaeological sites. The application was coordinated by the University of Birmingham: Artemise - Archaeo-geophysical Rover To Explore and Map In Submerged Environments.

## **FWF**

The project application "Automatic Rectification of Aerial Photographs" (ARAP) was accepted by the Austrian Science Fund (200,000 Euro). The project will start March 1<sup>st</sup> 2012 and be coordinated by the LBI ArchPro Partner VIAS - University of Vienna.

## **Torsten Söderberg Stiftelse**

The application for funding of state-of-the-art airborne laser scanning (ALS) and hyperspectral scanning of the Swedish Case study sites Birka-Hovgården and Uppåkra submitted by the Swedish LBI ArchPro partner RAÄ was successful in regard to the Uppåkra part (400,000 SEK). The first ALS flight is planned for spring 2012 and will be conducted by LBI ArchPro partner Airborne Technologies.

## **Further Outlook**

- Submission of an FP7-ICT project in Virtual Archaeology in April 2012
- Re-submission FP7-People Initial Training Network in January 2013

## **3. PARTNERS**

The LBI ArchPro (<http://archpro.lbg.ac.at>) is based on a European partnership formed by:

- **LBG** - Ludwig Boltzmann Gesellschaft (A)
- **NoeL** - Province of Lower Austria (A)
- **NIKU** - Norsk Institut for Kulturminneforskning (N) - The Norwegian Institute for Cultural Heritage - Archaeology Department
- **RAÄ** - Riksantikvarieämbetet (S) - UV Teknik
- **RGZM** - Römisch Germanisches Zentralmuseum (D)
- **VISTA** - University of Birmingham (GB) - The Visual and Spatial technology Centre (VISTA)
- **Uni Vienna** - University of Vienna (A) - Vienna Institute for Archaeological Science (VIAS) and Institute for Prehistory and Early Mediaeval History (UFG)
- **TU Vienna** - University of Technology Vienna (A) - Institute for Computer Graphics and Algorithms (ICG) and the Institute for Photogrammetry and Remote Sensing (IPF)
- **ZAMG** - Central Institute for Meteorology and Geodynamic (A)
- **Airborne Technologies** (A)

From September 1<sup>st</sup> 2011 a new partner has joined the LBI ArchPro - Airborne Technologies (**ABT**).

Airborne Technologies is a well established company for Airborne Surveillance, Remote Sensing & System Integration. We are manufacturer independent but have preferred aircraft and sensors providing most reliable and tailor made turnkey solutions. The TECNAM MMA – an efficient multi-fuel twin engine aircraft is developed, certified and marketed by Airborne Technologies and gives a complete new perspective for Airborne Special Services (Law Enforcement, Peacekeeping & Environmental Monitoring).

The company is situated in Wiener Neustadt (about 50 km south of Vienna). For six years ABT has been dealing with airborne remote sensing. The employed sensors are of the newest technology and range from laser scanner systems to imaging spectroscopy and thermal measuring systems.

LBI ArchPro - ABT Collaboration: ABT is operating an aircraft equipped among other with a hyperspectral sensor. Due to the partnership with the LBI ArchPro partner ABT seeks to increase to knowledge in the field of hyperspectral data acquisition under changing environmental condition and to get experience in the field of interpretation and classification of hyperspectral remote sensing data.

ABT will perform periodic test flight acquiring data from the project area in Zillingdorf next to Wr. Neustadt/Austria. These periodic flights will help to receive knowledge which seasonal and environmental conditions are best suited for Hyperspectral data acquisition missions.



### **Collaboration Partners**

Collaborative agreements for scientific research tasks and case studies exist with following organizations:

- University Lund, Department of Archaeology and Ancient History (S)
- Eastern Atlas GmbH & Co. KG (D)
- MALÅ Geoscience AB (S)
- Vestfold Fylkes Komune (N)
- Riegl - Laser Measurement Systems (A)
- Pico Envirotec Inc. (CDN)
- University of Bradford (GB)

## 4. BODIES

The Scientific Advisory Board of the LBI ArchPro will consist of the following distinguished scientists:

**Prof. Kay Kohlmeyer**, Hochschule für Technik und Wirtschaft (HTW) Berlin (D)

**Prof. Julian Richards**, University of York (GB)

**Prof. Joakim Goldhahn**, Linnaeus University, (S)

**Prof. Maurizio Forte**, University of California, Merced (USA)

**Prof. Sarah Parcak**, University of Alabama (USA)

The next SAB meeting is planned for June 2012.

## 5. LBI ARCHPRO TEAM

The Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology has employed 18 staff in 2011:

- Wolfgang Neubauer (Director)
- Michael Doneus (Deputy Director)
- Matthias Nöster (Operations Manager)
- Rosa Enn (Administration Manager)
- Elisabeth Schadek (Administration Manager)
- Karolin Kastowsky-Priglinger (Administration Manager)
- Christian Briese (Researcher)
- Geert Verhoeven (Researcher)
- Michael Pregesbauer (Researcher)
- Agata Klimczyk (Researcher)
- Immo Trinks (Key Researcher)
- Alois Hinterleitner (Key Researcher)
- Klaus Löcker (Researcher)
- Matthias Kucera (Researcher)
- Erich Nau (Researcher)
- Thomas Zitz (Researcher)
- Nives Doneus (Key Researcher)
- Vlad Sandici (Researcher)

## 6. INFRASTRUCTURE

### Remote Sensing

- OPALS Software Package (IPF)
- SCOP++ and TopDM Software packages (UFG)
- Trimble GPS Geo XM S/N inkl. accessories
- Camera systems: Hasselblad H2D, Nikon D700, Nikon D90NIR, Nikon D2X
- Scanner: Vexcel UltraScan 5000 - photogrammetrical high-resolution scanner (UFG)
- Leica Photogrammetry Suite (UFG)
- OceanOptics Jaz-Combo Spectrometer (LBI ArchPro)
- ENVI Software Package (IPF)
- ERDAS Imagine Professional (UFG)

### **TLS (Terrestrial Laserscanning)**

- 1 Riegl LMS 3D Laser Scanner Z210 (UFG)
- 1 Riegl LMS 3D Laser Scanner Z420i (VIAS)

### **Ground Penetrating Radar (GPR)**

- Manually operated single channel Sensors & Software - PulseEKKOPro 500 MHz (VIAS)
- Motorized six channel Sensors & Software SPIDAR system (six PulseEKKO Pro 500 MHz) (VIAS) mounted on a custom built aluminum trailer (LBI ArchPro); a similar second system is currently under construction (ZAMG)
- MALÅ Imaging Radar Array (MIRA) - 16 channel GPR 400 MHz system (VISTA), mounted in front of a Kubota compact tractor (LBI ArchPro)

### **Magnetometry**

Fluxgate magnetometry:

- 15 Foerster gradiometer probes (RAÄ)
- 10 channel Eastern Atlas digitizer (LBI ArchPro)
- 5 channel Eastern Atlas digitizer (LBI ArchPro)
- 2 non-magnetic sensor carts (VIAS / RAÄ)

Caesium magnetometry:

- 1 AMMS8G Pico Envirotec magnetometer unit inclusive 4 Scintrex CS3 Caesium sensors (RAÄ)
- 2 AMAG-4 Pico Envirotec magnetometer unit inclusive 4 Scintrex CS2 and 1 Scintrex CS3 Caesium sensors (ZAMG)
- 1 AMAG-4 Pico Envirotec magnetometer unit inclusive 5 CS2 Caesium sensors (VIAS)

### **Motorized survey vehicles:**

- 3 All-Terrain-Vehicles (ATV) - TGB Blade (VIAS, LBI ArchPro, VISTA)
- 1 Kubota compact tractor (LBI ArchPro)

### **RTK-GPS:**

- 1 Leica GPS 1200 consisting of 1 Base + 1 Rover (VIAS)
- 3 JAVAD Triumph 1 GNSS receiver (1 base, 2 rovers) (LBI ArchPro)

### **Total Station:**

- 1 Leica TCRP 1203 (VIAS)
- 1 Leica Tachymat TCRP1205 R300 Smart Station (including GPS) (UFG)

### **Vehicles :**

- 1 Mercedes Sprinter (ZAMG)
- 1 VW Transporter (VIAS)
- 1 VW Transporter (LBI ArchPro)
- 6 trailers (VIAS, LBI ArchPro, ZAMG, VISTA)

### **Offices & Workshops:**

- University of Vienna, Franz Kleingasse 1/V (130 m<sup>2</sup>)
- ZAMG, Hohe Warte 38, 1190 Vienna (125 m<sup>2</sup>)

- Föllim, Lower Austria (Vehicle shelter)



## 7. HIGHLIGHTS 2011

### Press Conference for the release of the sensational discovery of the Gladiator School in Carnuntum, September 5<sup>th</sup> 2011

At Roman Carnuntum, one of the largest preserved archaeological landscapes of its type in Europe, the LBI ArchPro team used novel motorized multi-antenna ground penetrating radar to explore interesting features identified by earlier investigations of partners ZAMG and VIAS. Following survey of this area archaeologists were astounded when the new sensors revealed an extensive building complex interpreted as a school for gladiators (Latin - *ludus*). The exceptional building, identified through this rapid survey as the school for gladiators, is almost unique in the Roman Empire for its size and completeness.

At the press conference in Carnuntum the LBI ArchPro and its partner NoeL (represented by LBI ArchPro director Wolfgang Neubauer) as well as Mag. F. Humer and Mag. M. Wachter (Archäologie Park Carnuntum) and Dr. E. Pröll (Governor of Lower Austria) proudly presented the sensational discovery of the gladiator school in Carnuntum.



Press information regarding the discovery of the school of gladiators can be found under

<http://www.carnuntum.co.at/>

<http://www.noe-landesausstellung.at/noel>

<http://www.facebook.com/carnuntum.co.at>

The keyword search for the search terms „Gladiatoren", "Carnuntum", "Gladiator-School" resulted in a search for the time frame 05.09.2011 – 15.09.2011

- in over 20,000 hits using Bing search engine,
- in over 21,000 hits using Google search engine.



## 8. PUBLIC RELATIONS

### Press releases and press coverage summary

#### LBI ArchPro

- <http://www.airbornetechnologies.at/nc/media/story/article/german-police-airops-capabilities-enhanced-with-the-introduction-of-a-vulcanair-p68-equipped-by-ai.html?cHash=a973d8b8bd66086ba99e3c58dad5b87e&print=1>
- <http://diepresse.com/home/science/692285/Magnetfelder-und-Radar>

#### Carnuntum

- <http://www.bbc.co.uk/news/world-europe-14795756>
- <http://derstandard.at/1315005480799/Fund-Praesentation-Die-Gladiatorenschule-von-Carnuntum>
- <http://www.spiegel.de/wissenschaft/mensch/0,1518,784360,00.html>
- <http://www.dailymail.co.uk/news/article-2034020/Archaeologists-discover-remains-Roman-gladiator-school-Austria.html?ito=feeds-newsxml>
- <http://noe.orf.at/stories/536068/>
- <http://www.independent.co.uk/life-style/history/ruins-reveal-how-roman-gladiators-won-their-spurs-2349802.html>
- [http://www.boston.com/news/world/europe/articles/2011/09/06/gladiator\\_ruins\\_discovered\\_in\\_austria/](http://www.boston.com/news/world/europe/articles/2011/09/06/gladiator_ruins_discovered_in_austria/)
- <http://www.bellinghamherald.com/2011/09/05/2170623/experts-roman-gladiator-school.html>
- <http://www.eluniversal.com.mx/notas/791095.html>
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- [http://www.wienerzeitung.at/themen\\_channel/wzwissen/geschichte/394376\\_Antike-Gladiatorenschule-in-Carnuntum-sicherlich-nicht-die-letzte-Entdeckung.html](http://www.wienerzeitung.at/themen_channel/wzwissen/geschichte/394376_Antike-Gladiatorenschule-in-Carnuntum-sicherlich-nicht-die-letzte-Entdeckung.html)
- <http://historyoftheancientworld.com/2011/09/school-for-roman-gladiators-discovered-in-austria/>
- <http://www.alltomhistoria.se/nyheter/colosseums-gladiatorskola-far-konkurrens/>
- <http://www.archaeologik.blogspot.com/>
- <http://english.aljazeera.net/video/europe/2011/09/2011964401518417.html>
- <http://english.ruvr.ru/2011/09/05/55703514.html>
- [http://www.nzherald.co.nz/lifestyle/news/article.cfm?c\\_id=6&objectid=10749780](http://www.nzherald.co.nz/lifestyle/news/article.cfm?c_id=6&objectid=10749780)
- <http://www.washingtontimes.com/news/2011/sep/5/unique-roman-gladiator-ruins-unveiled-in-austria/>
- <http://www.ibtimes.com/articles/206643/20110831/roman-amphitheater-uncovered-vienna-austria-colosseum-sized-archaeological-park-carnuntum.htm>
- <http://english.aljazeera.net/video/europe/2011/09/2011964401518417.html>
- <http://www.vol.at/gladiatorenschule-in-carnuntum-als-sensationsfund/apa-1145127264>
- <http://www.wirtschaftsblatt.at/archiv/carnuntum-gab-sensation-preis-486846/index.do>
- <http://www.n-tv.de/wissen/fundsache/Reste-einer-Gladiatorenschule-article4231116.html>
- [http://www.focus.de/wissen/wissenschaft/anthropologie/sensationeller-fund-in-oesterreich-archaeologen-entdecken-gladiatorenschule\\_aid\\_662592.html](http://www.focus.de/wissen/wissenschaft/anthropologie/sensationeller-fund-in-oesterreich-archaeologen-entdecken-gladiatorenschule_aid_662592.html)
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- <http://grenzwissenschaft-aktuell.blogspot.com/2011/09/archaeologen-finden-gladiatorenschule-in.html>
- <http://www.wochenblatt.de/nachrichten/welt/Ruinen-roemischer-Gladiatorenschule-bei-Wien-entdeckt;art29,65647>
- <http://www.heute.at/news/oesterreich/noe/Gladiatorenschule-in-Carnuntum-als-Sensationsfund;art932,595453>

- [http://www.krone.at/Wissen/Erste\\_Bilder\\_der\\_Gladiatorenschule\\_in\\_Carnuntum-1.700\\_Jahre\\_alt-Story-294334](http://www.krone.at/Wissen/Erste_Bilder_der_Gladiatorenschule_in_Carnuntum-1.700_Jahre_alt-Story-294334)
- <http://science.orf.at/stories/1687541/>
- <http://www.thehindu.com/sci-tech/energy-and-environment/article2429987.ece>



- <http://news.nationalgeographic.com/news/2011/09/110913-gladiator-school-austria-roman-ancient-walmarts-science/>
- [http://diepresse.com/home/panorama/oesterreich/690859/Sensationsfund\\_Gladiatorenschule-in-Carnuntum](http://diepresse.com/home/panorama/oesterreich/690859/Sensationsfund_Gladiatorenschule-in-Carnuntum)
- <http://kurier.at/nachrichten/niederoesterreich/4149036.php>
- [http://www.ots.at/presseaussendung/OTS\\_20110905\\_OTS0139/lh-proell-entdeckung-der-gladiatorenschule-in-carnuntum-ist-eine-archaeologische-sensation](http://www.ots.at/presseaussendung/OTS_20110905_OTS0139/lh-proell-entdeckung-der-gladiatorenschule-in-carnuntum-ist-eine-archaeologische-sensation)
- <http://www.noen.at/news/chronik/Schule-der-Gladiatoren;art151,345342>
- <http://de.wikipedia.org/wiki/Carnuntum>
- <http://www.salzburg.com/online/nachrichten/kultur/Gladiatorenschule-in-Carnuntum-als-Sensationsfund.html?article=eGMmOI8VeHf1TjFQzCT9gDJGZfZAiOX6NXF7xle&img=&text=&mode=&>
- <http://www.descopera.ro/dnews/8718885-o-scoala-antica-de-gladiatori-a-fost-descoperita-in-austria>
- <http://www.semana.com/mundo/hallan-escuela-gladiadores-romanos-austria/163702-3.aspx>
- [http://m.nrk.no/m/artikkel.jsp?art\\_id=17780362](http://m.nrk.no/m/artikkel.jsp?art_id=17780362)
- <http://natgeo.se/ur-och-forntid/arkeologi/enorm-gladiatorskola-hittad-i-wien>

#### **Stubersheim**

- <http://web.rgzm.de/1154.html>
- <http://www.archaeologie-online.de/magazin/nachrichten/view/ohne-grabung-ausgegraben-grossflaechige-prospektion-auf-der-schwaebischen-alb/>

- [http://www.swp.de/goeppingen/lokales/mittleres\\_filstal/Stubersheimer-Alb-wird-erforscht;art5777,854278](http://www.swp.de/goeppingen/lokales/mittleres_filstal/Stubersheimer-Alb-wird-erforscht;art5777,854278)
- <http://www.aftenposten.no/nyheter/iriks/article4111824.ece>



#### **Birka**

- <http://sverigesradio.se/sida/artikel.aspx?programid=2108&artikel=4551633>
- <http://sverigesradio.se/sida/gruppsida.aspx?programid=407&grupp=11957&artikel=4522975>
- <http://www.malags.com/mala-gpr-user-success-stories/archaeological-research>
- <http://www.stomma.se/sv/Birka/ATT-GORA/publik-arkeologi-/>
- <http://www.geomatiknyheter.se/2011/06/birka-ska-gr-vas-ut-virtuellt>
- [http://www.ots.at/presseaussendung/OTS\\_20110524\\_OTS0069/lbi-archpro-erstellt-virtuelles-modell-der-schwedischen-wikingerstadt-birka](http://www.ots.at/presseaussendung/OTS_20110524_OTS0069/lbi-archpro-erstellt-virtuelles-modell-der-schwedischen-wikingerstadt-birka)
- [http://www.arkeologiuv.se/cms/arkeologiuv/aktuellt\\_uv/prospektering/birka.html](http://www.arkeologiuv.se/cms/arkeologiuv/aktuellt_uv/prospektering/birka.html)
- [http://www.arkeologiuv.se/cms/showdocument/documents/extern\\_webbplats/arkeologiuv/uppdrag\\_uv/prospektering/prospektering\\_vid\\_birka.pdf](http://www.arkeologiuv.se/cms/showdocument/documents/extern_webbplats/arkeologiuv/uppdrag_uv/prospektering/prospektering_vid_birka.pdf)

#### **Uppåkra**

- <http://www.dik.se/www/dik/web.nsf/dx/110513-Historien-upp-till-ytan>
- <http://www.sydsvenskan.se/omkretsen/lomma/article1473390/Ny-metod-gor-Uppakra-aldre.html>
- <http://www.sydsvenskan.se/omkretsen/lomma/article1473366/Dold-cirkel-vacker-nyfikenhet.html>
- <http://www.sydsvenskan.se/omkretsen/article1508520/Unik-gravkammare-i-Uppakra-tom-pa-svar.html>
- <http://www.uppakra.se/gravdagbok/2011-07-07-nu-ar-gravkammarbomben-slappt/>
- <http://www.uppakra.se/gravdagbok/2011-05-15-mer-om-arkeologisk-prospektering/>
- <http://www.uppakra.se/gravdagbok/2011-05-11-stenkonstruktion-och-geofysiska-matningar/>

#### **Stonehenge**

- [http://www.youtube.com/watch?v=gKlq\\_6eyJLo](http://www.youtube.com/watch?v=gKlq_6eyJLo)
- <http://www.brad.ac.uk/mediacentre/press-releases/title-27133-en.php>
- <http://www.independent.co.uk/life-style/history/secret-history-of-stonehenge-revealed-6268237.html>

- <http://www.birmingham.ac.uk/news/latest/2011/11/25Nov-Discoveries-provide-evidence-of-a-celestial-procession-at-Stonehenge.aspx>
- <http://backstory.blogs.cnn.com/2012/01/06/the-revealer-virtual-archaeology/?iref=allsearch>
- The Hindu: [file:///C:/LBI\\_CaseStudies/Stonehenge/Stonehenge%20Presse%202011/article2665474.ece.htm](file:///C:/LBI_CaseStudies/Stonehenge/Stonehenge%20Presse%202011/article2665474.ece.htm)
- Digital Journal: [file:///C:/LBI\\_CaseStudies/Stonehenge/Stonehenge%20Presse%202011/digital%20journal315070.htm](file:///C:/LBI_CaseStudies/Stonehenge/Stonehenge%20Presse%202011/digital%20journal315070.htm)
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#### **Vestfold**

- <http://www.nrk.no/nyheter/distrikt/ostafjells/vestfold/1.7619098>
- [http://www.vfk.no/default.aspx?sc\\_itemid={13481BF5-01A3-40BF-8CA2-B008CD4B1C4A}](http://www.vfk.no/default.aspx?sc_itemid={13481BF5-01A3-40BF-8CA2-B008CD4B1C4A})

#### **Burgen-Messe Stetteldorf**

On March 13<sup>th</sup> the LBI ArchPro together with its partners VIAS and ZAMG participated on a fair concerning the restoration and conservation of historical buildings to show the potential of non-invasive methods like GPR, magnetometry and 3D Laser Scanning. Target audience of the exhibition were mainly private landowners who often restore and modernise their historical properties in years of careful work. The stand found great response within the audience and we were able to discuss and solve many inquiries and problems. An often discussed problem was the question of old garden structures, cellars or other hollow spaces where we could show our expertise and know-how within this field. The great response led to an invitation for the Exhibition 2012.

#### ***Junge Uni Waldviertel 2011***

In the course of the "Junge Uni Waldviertel 2011", a project of the "Regional collaboration of the Czech Republic and Austria" funded by the EU held in Raabs ad. Thaya/Lower Austria (August 15<sup>th</sup>-19<sup>th</sup>), the LBI ArchPro was asked to hold lectures about modern archaeological work emphasising on archaeological prospection and the LBI ArchPro programme. Three talks a 45 minutes were held by Karolin Kastowsky for around 80-100 kids aged 10-14. The fascination of the theme itself and the modern approach of the LBI ArchPro were well embraced by the youth and resulted in animated discussions and interesting questions. Key-words like radar, magnetics, 3D Laser Scanning and the prospect of an archaeological work based on computer and such alike were fascinating and for most of the kids new approaches into modern archaeology. All the talks were translated simultaneously into Czech.

#### ***Birka Visitor Centre***

During the fieldwork conducted at the case study site Birka in Sweden an information-container provided by partner RAÄ was set up centrally into the area of investigation equipped with a computer monitor, laptop and power generator for public data processing and display of latest results. Posters informing about the case study and explaining the used methods in Swedish and English language were mounted in the container. A press conference was held on Tuesday May 24<sup>th</sup> on Birka in collaboration with RAÄ-UV, RAÄ, Strömme and MALÅ Geoscience presenting the case study, methodology, technology and earlier archaeological prospection results, resulting in national and international media coverage in TV, radio and print. Several presentations were given by members of the LBI ArchPro to the visitors of Birka in Swedish and English, attracting considerable attention. Dedicated guided tours were given by Strömme tourist guides explaining the LBI ArchPro project and background. First archaeological prospection results were presented at the Birka visitor centre to the partner RAÄ-UV, members of the Historical Museum in Stockholm, staff from RAÄ and Strömme and to local residents. A contribution with archaeological prospection material to an international exhibition on Vikings organized by the Historical museum and Austrian specialists was discussed on site and agreed upon.



### ***Uppåkra museum***

For the case study Uppåkra in Sweden a well attended presentation of the LBI ArchPro project, preliminary results and technology used was given to the local project partners in form of a seminar of the Department of Archaeology and Ancient History of Lund University on site in Uppåkra museum. As a result several students participated in the fieldwork. The results were specifically discussed with Håkan Thorén, Bengt Söderberg and Prof. Lars Larsson. Four posters were prepared for display on site with LBI ArchPro partner RAÄ.



# RESULTS

## 1. ARCHAEOLOGICAL REMOTE SENSING

### **WP Perform repeated test-flights**

Repeated test flights are being performed both for ALS and AHS in accordance with partner NoEL. The second flight was performed on May 26<sup>th</sup> 2011, at the beginning of the cropmark season over the case-study areas Carnuntum, Kreuttal, St. Anna and Lichtenwörth. At the same time, oblique photographs were taken over the case study areas of Carnuntum and Lichtenwörth (both with RGB and NIR cameras).

Due to exceptional archaeological results over the area of the civil-town of Carnuntum (Iudus), partner Uni Wien (UFG) gave an order to its military contract-partner in Langenlebar to perform a vertical coverage, which was done at the end of May 2011.

A third test-flight was prepared and performed on July, 11<sup>th</sup> over Carnuntum and Kreuttal and Lichtenwörth (both for ALS and AHS) and a fourth test-flight during October and November. A thermal flight was performed over Carnuntum on 27.10.2011 (daytime) and 30.10.2011 (night time). Carnuntum and St. Anna were scanned (AHS & ALS) on November, 11<sup>th</sup>, Kreuttal on November 26<sup>th</sup> in accordance with our project partners NoEL and ABT.

### **WP Geo-referencing of repeated test flights**

Within this WP several discussions with team members were organised and geo-referencing of the ALS and AHS data was prepared, which is done at partner TU Vienna.

### **WP Advanced DTM generation for archaeological interpretation**

Within this WP research in the research of advanced filter methods towards improved DTM generation with *Software opals* was started. With the new opals module opalsRobFilter first results were determined and the module was further tested and analysed.

The ALS and TLS data set St. Anna was further studied. Within this research work new visualisation possibilities of full-waveform ALS data in combination with TLS data were developed and practically tested.

Work on advanced DTM generation for archaeological interpretation is proceeding. The aim is to gather information about chosen ALS software packages, which are capable of filtering ALS point clouds in order to get bare-earth points. The main objective will be to investigate the filtering procedures used by the software, precision of the results and difficulties that occurred during the work. From the archaeologist's point of view the filtering function is very important in wooded areas. Therefore as test fields four areas in woods of St. Anna have been chosen. Each represents different density of the canopy, understory and different shape of the terrain (slope).

The primary set of software to be tested has been already chosen. That is why an idea of making this project more flexible has been proposed. It may be profitable to create a webpage where: the current results are published, may be changed, new can be added and the visitors may also add their comments or even test the software. It would make the research interactive and up to date.

Currently one test area is being investigated. For this area the following steps have been done:

- Manual filtering of the point cloud in DTMaster software package.
- Field control.
- Two open source packages have been tested: FUSION, MCC .
- For each step of work a report has been created.
- The SAGA software package is currently being tested.
- Research of advanced filter methods towards improved DTM generation with *opals* was started.
- Additionally, a co-operation was launched with partner NIKU to use radiometric calibration results to enhance the filtering of ALS point clouds.

Also within this WP one data set provided by partner NIKU (Larvik) was studied and first results were presented. Additionally, a co-operation was launched with NIKU to use radiometric calibration results to enhance the filtering of ALS point clouds.

### **WP Radiometric calibration of ALS data**

Based on the ALS data set Carnuntum the radiometric calibration with the program package *opals* has led to successful results. For the calibration the simultaneously acquired reflectometer observations were used and based on these observations the whole ALS data set was calibrated.

The results showed crop marks, which were interpreted. The results will be compared to the interpretation of the contemporary RGB-images.



The existing workflow for radiometric calibration was later on extended to the usage for multi-wavelength ALS data. Practical tests with multi-wavelength data were performed and the results were submitted in a paper for the ISPRS congress in Melbourne (August 2012).

### **WP Geo-referencing, filtering, DTM generation and archaeological interpretation of ALS data from repeatedly scanned project areas**

Co-operation was launched with partner NIKU to set up a workflow for monitoring changes in the DTM at the site of Mølen (case-study area Larvik/Vestfold).

### **WP Review on theory, technology, methodology, and archaeological applications of AHS**

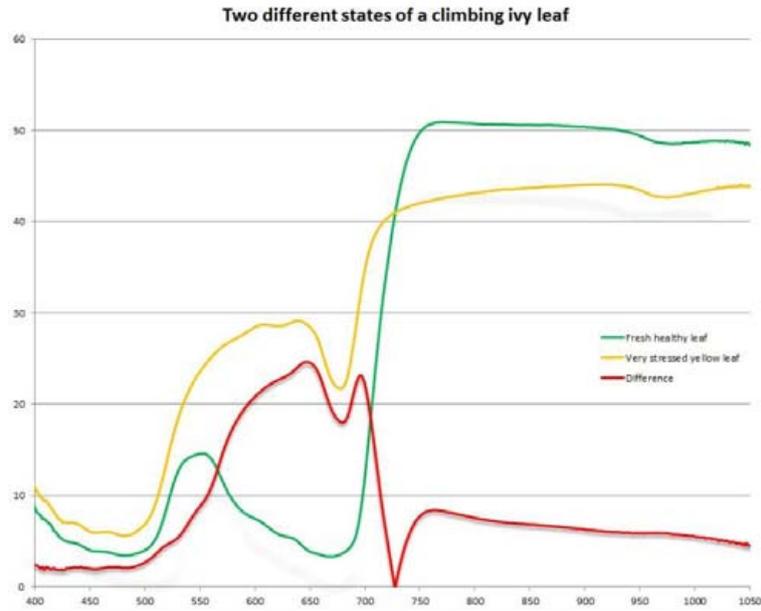
The work was concentrating on reviews on theory and methodology, collecting ground data with a spectrometer and repeated scanning of sample-areas.

Most publications on archaeological imaging spectroscopy are collected and integrated in a database. After some enquiries, two different Red Edge filters were purchased and tested on their spectral transmission. To this end, some test targets were bought and constructed. They were used already once to verify the resolution of conventional oblique images.

### **WP Systematically collected ground-based measurements using a spectrometer**

One AHS flight was done, for which field spectroscopic measurements were collected. These data are now almost completely processed and a new database has been built to store all the spectral curves, the still images of the sample locations and all related metadata.

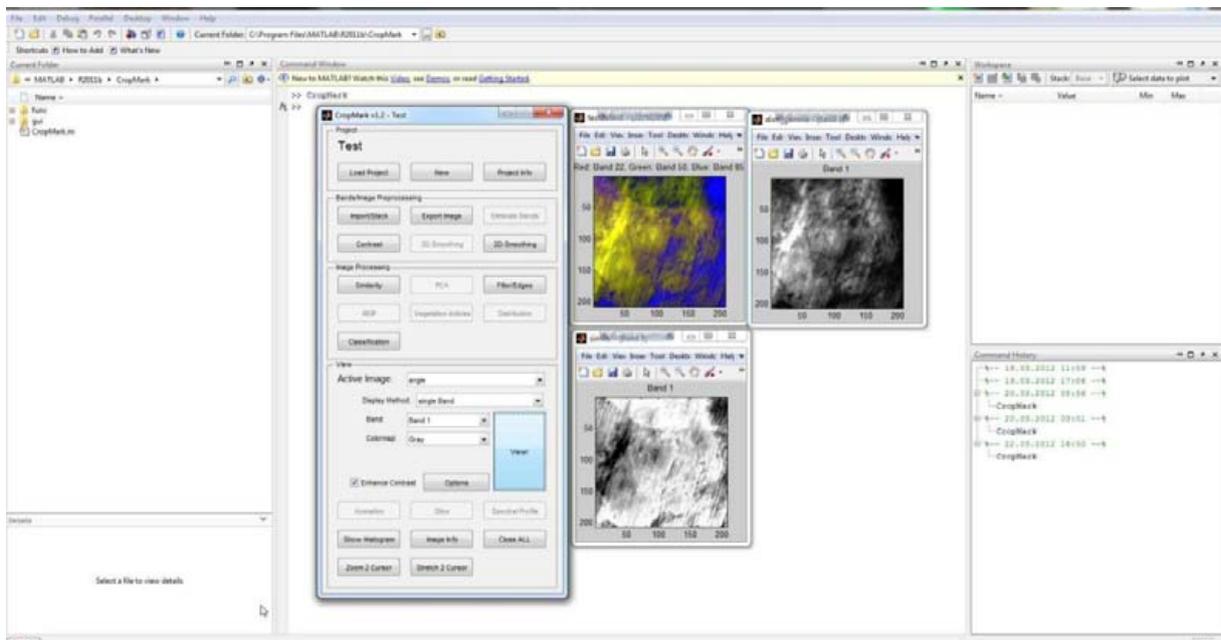
Provided by partner Uni-Vienna (UFG) a new spectrometer could be put in option (SVC Ger 1500) and tested. Currently, a design is made for attaching the spectrometer in such a way that its handling is optimised and the spectral data are as repeatable as possible. Included is an image that shows the stable behaviour of the SVC 1500 over the 450 nm to 1050 nm range. It shows the spectral reflectance of a healthy (green) and stressed (yellow) climbing ivy leaf as well as their spectral difference – which is clearly biggest in the Green-Red and Red edge region.



**WP Systematically investigation of possibilities for information extraction and analysis**

The software package ENVI was provided by partner Uni-Vienna. A discussion, regarding potential co-operation with BOKU-Wien, was held with Clement Atzberger (remote sensing specialist airborne imaging spectroscopy). Together with Prof. Atzberger, a tool-box for archaeological analysis of AHS data was specified. The toolbox will be financed by partner UFG and written by Clement Atzberger using Matlab.

A beta-version was first time presented at the IC-ArchPro Workshop 1 in November. Discussion on preliminary results and ideas for further developments were made during December.



## WP Data fusion of AHS datasets and ALS data

Together with Camillo Ressel from partner TU-Vienna an advanced geo-referencing of the AHS data was developed. A workflow was implemented at IPF TU-Vienna and first successful georeferencing results were delivered for further analysis in the beta-version of the analysis toolbox.

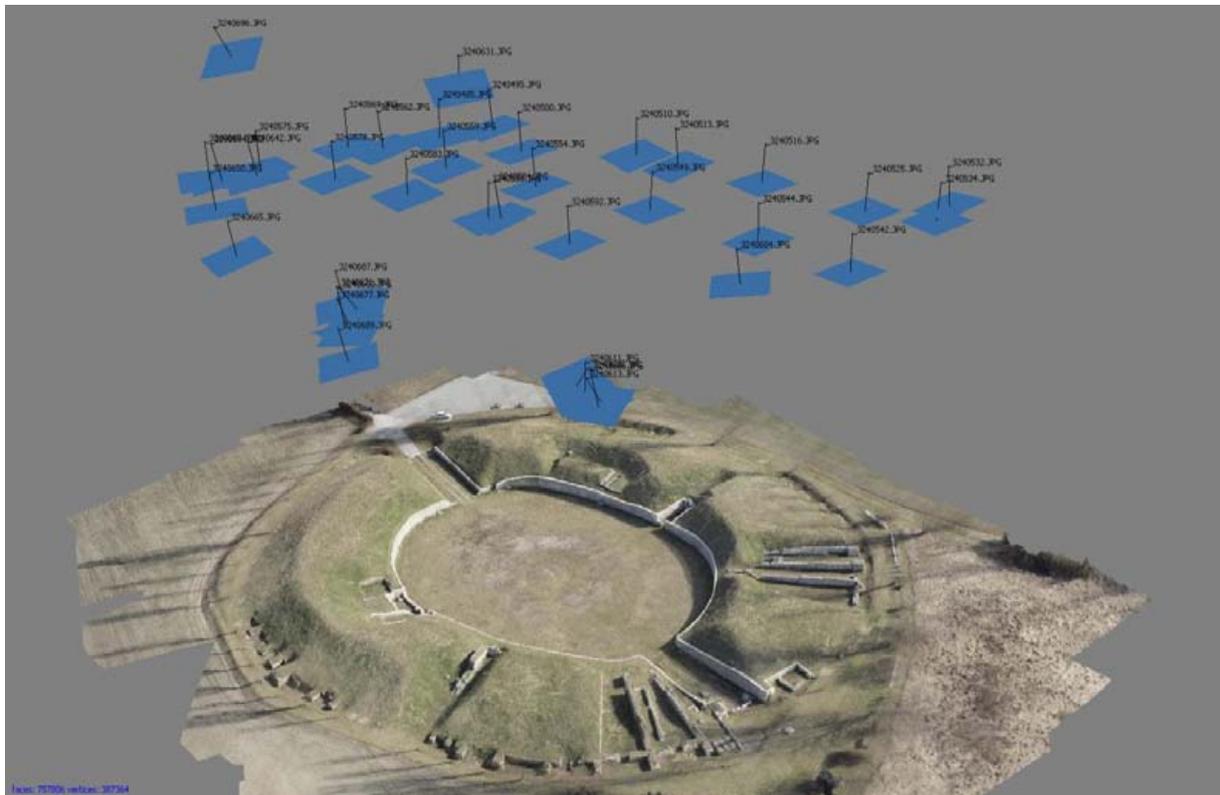
Within several meetings also together with the new LBI ArchPro partner ABT the next research steps in AHS mapping were fixed.

The project application “Automatic Rectification of Aerial Photographs” (ARAP) was accepted by the Austrian Science Fund (200.000 Euros). The project started on March 1<sup>st</sup> 2012.

Since aerial archaeology desperately needs new approaches for fast and accurate orthorectification, many days have been devoted to the development of a new workflow that allows the semi-automatic generation of orthophotos. To this end, a wide variety of existing ground-based and aerial datasets were used to test whether or not these photographs could easily be orthorectified. In the end, a complete workflow was developed, including point cloud cleaning and mesh optimization to generate orthophotos of almost any unordered photo collection of photographs. Many commercial and various open-source software solutions were tested and compared. The current workflow is largely based on the commercially available package PhotoScan. This software relies on computer vision algorithms complemented by proven photogrammetry principles, to permit the semi-automatic transformation of an unordered photo set into a Digital Surface Model (DSM) and corresponding orthophotograph.

The results of all this testing were written down in two papers: a general one on aerial images submitted in the Journal of Archaeological Science and a more specific one using excavation photographs. The latter paper, which was submitted as a peer-reviewed paper for the CIPA Symposium in Prague (“From deposit to point cloud – a study of low-cost computer vision approaches for the straightforward documentation of archaeological excavations”) also focused on the evaluation of the final accuracy of the generated products by following the American National Standard for Spatial Data Accuracy guidelines.

Besides the existing photo sets, new imagery was acquired to verify and validate the approach: on an excavation site in Kreuttal and of Carnuntum’s Heidendor and Ludus area.



## 2. ARCHAEOLOGICAL GEOPHYSICAL PROSPECTION

### **WP Test and large scale magnetic surveys and application of the motorized magnetometers in the framework of the case studies for the analysis and reduction of effects and disturbances caused by micro-topography**

Some 80 hectares of area were surveyed in Austria in the context of the Kreuttal case study testing the motorized Foerster magnetometer systems with Eastern Atlas digitizers as well as the new Foerster PNC magnetometer system. These tests resulted in the formulation of first Best Practice manuscripts regarding magnetic data processing.

At Uppåkra the simultaneous use of two motorized Foerster magnetometer systems was implemented successfully testing one 5-channel and one 10 channel Eastern Atlas digitizer.

Considerable areas of over one square kilometre were covered in high resolution, resulting in the discovery and mapping of numerous archaeological structures. It was possible to demonstrate that the positioning accuracy of the new geomagnetic data relative to archaeological excavation results from the year 2000 was approximately 10 cm.

It was further possible to demonstrate that the cause of two geomagnetic anomalies that had been mapped in 1997 by a team from Kiel University were still in place – despite the fact that an archaeological trial excavation aimed at investigating the source of the magnetic anomalies did not report any finds which could explain the measurements – reportedly undisturbed soil had been located in approximately 40 cm depth. The actual cause of these (and many other anomalies in the area) appears to be buried due to colluvial accumulation at greater depth.

The novel Foerster magnetometer system consisting of three 4-channel PNC boxes, 10 gradiometer probes and custom made cabling was prepared for field use and mounted weatherproof on a nonmagnetic cart. The 12-channel system was for the first time tested at Stonehenge with 10 Foerster gradiometer probes (65 cm vertical sensors spacing) in waterproof casings using 25 cm cross-line spacing between the probes.

### **Motorized TLS**

A tower and rig for elevated mounting of a terrestrial laser scanner (Riegl LMS Z420i) in front of the Kubota tractor was designed and custom built. The system was successfully tested and employed at Uppåkra for the digitalization of large parts of the central case study area. DTM data derived from TLS as well as LiDAR will be used for topographic correction of the geophysical prospection data.

A diploma thesis about the interpretation of the archaeological prospection results from the case study Uppåkra 2010 was written and defended with honours by Manuel Gabler, who had participated in both fieldwork campaigns 2010 and 2011 and studied the site during two weeks in May 2011 with support from LBI ArchPro partner RAÄ and collaboration partner Lund University.

An additional motorized tow vehicle for magnetic measurements was commissioned (moon-rover) and tested and a training video compiled.



### **WP Test and large scale GPR surveys in framework of the case studies for the analysis and reduction of effects and disturbances caused by micro-topography**

A high-definition MIRA survey was conducted in front of Uppåkra churchyard on a circular structure discovered in 2010 by manual GPR measurements (25 cm spacing). The new data was able to image the structures in considerably higher resolution, as well as additional structures of archaeological interest, such as a road and several pits.

This main structure (a circular  $\sim 10$  m  $\varnothing$  stone circle with central stone setting/grave) was selected by collaboration partner University Lund and RAÄ (Bengt Söderberg) for archaeological trial excavation. The trial excavation of the predicted grave resulted in excellent agreement between the prospected /mapped and subsequently excavated structures.

Due to the heavy and continuous use of the MALÅ Imaging Radar Array (MIRA) a custom made skid-plate for added protection was mounted on the bottom of the antenna casing, and reserve skid-plates were prepared.

In September 2011 the initial MIRA antenna box with 8 cm channel spacing was exchanged against a new antenna box since fractures due to the heavy use had compromised the weather/water proofing.

The ground-probing and archaeological excavation of several cooking pits at Lunde/Tjøllingvollen in Vestfold, which were discovered during the 2010 case study with magnetic and GPR measurements, was supported by members of LBI ArchPro and the Norwegian partners NIKU and Vfk.

During the Birka case study all accessible areas on the island were mapped using magnetic and high definition GPR prospection, resulting in high quality archaeological data.

At Birka considerable test measurements with the SPIDAR network GPR system were conducted. Observed weaknesses in regard to power supply and system performance were reported to the manufacturer and partly remediated. Discussions with the manufacturer, who is intensively working on solutions related to data acquisition software issues, are ongoing.

### **WP Development, improvement and application of manually operated multichannel and multi-frequency GPR systems and multi-sensor magnetometers**

Prior to the case study Stonehenge a manual Caesium magnetometer cart was put in operation and thoroughly tested. The Swedish six channel Caesium magnetometer system was for the first time successfully taken into operation. Special sensor mountings for the measurement of three parallel true gradients with variable heights were designed, built and mounted. An initial test survey was successfully conducted in collaboration with LBI ArchPro partner ZAMG in the tunnels of the geomagnetic observatory Traffelberg. As intended it was possible to detect all present geomagnetic anomalies with high accuracy - and to verify a proper functioning of the system.

During the case study Stonehenge elaborate comparative test surveys using six CS3 sensors mounted in different heights above ground and with different sensor gradients were carried out with the above mentioned modified cart.

Trial measurements for the mapping of underwater archaeology using a GPR antenna mounted inside a small boat in combination with RTK-GPS positioning were conducted on Lake Attersee in Austria and on the Danube River in Vienna.

A new second cart for the SPIDAR system has been built in stainless steel (instead of aluminium) and taken into operation.



### **WP Optimization of magnetometer sensor arrangements through systematic evaluation of various sample spacing and sensor arrangements. Study of different gradiometer arrays**

Comprehensive systematic evaluations of Caesium magnetometer sensor height above ground, different gradients between sensors, single sensor versus gradiometer setup as well as horizontal sensor spacing (25 cm versus 50 cm) were carried out at Stonehenge through numerous repeated surveys across the new henge structure G50 discovered in 2010. The data was thoroughly analysed and recommendations were made for optimized sensor placement. The results of this study are currently being compiled for scientific publication.



### **WP Integration and adaptation of suitable positioning devices**

Three new JAVAD RTK-GPS receivers and base stations were tested and integrated into the magnetometer and GPR prospection systems for the case study Stubersheim.

Three additional JAVAD RTK-GPS were commissioned for the case study Stonehenge - permitting with the simultaneous use of two 10 channel motorized magnetometer systems unprecedented magnetic coverage of over two square kilometres within 14 days.

In Vestfold the survey area Kaupang was re-surveyed with the MIRA system using RTK-GPS positioning instead of totalstation, resulting in considerably improved data positioning and depth-slice images. Time-triggering of the GPR measurements instead of Odometer triggering was successfully tested.



### **WP Integration and adaptation of suitable navigation devices**

The data logging and navigation software LoggerVis was user-optimized and considerably improved through integration of the new Foerster PNC magnetometer system. LoggerVis now permits the display of simple magnetometer data in realtime as background of the navigation and data logging screen, for instant data quality control and first in-field analysis. Queries into possibilities for advanced positioning systems in complex environments were undertaken. Novel optical positioning devices were tested.

All devices and components used in Foerster magnetometer prospection were labelled and possibilities for their exact identification integrated into LoggerVis, permitting improved data analysis and problem detection/elimination.

### **WP Development of advanced and effective data pre-processing algorithms for the new huge data sets of GPS positioned measurement geometries of the novel motorized multi-sensor surveys for magnetics und GPR**

The data processing software ApMag was continuously adapted and improved - resulting in much improved data filtering and imaging possibilities, amongst others through integration of filter based on statistical data analysis.

The in-house developed magnetic data logging and navigation software LoggerVis was rapidly adapted for the new Foerster PNC magnetometer system - providing now a single interface for both Eastern Atlas and Foerster PNC digitizers. Functionality and data format were enhanced.

A common XML based data format was designed and implemented in LoggerVis, gathering all relevant information and data in an efficient manner.

Large amounts of raw data were copied for backup purpose onto the new LBI ArchPro ftp-server using a common practical file structure.

## **3. ARCHAEOLOGICAL INTERPRETATION, SPATIAL ANALYSIS & VIRTUAL ARCHAEOLOGY**

### **WP Definition of data exchange formats, geodatabases and according interfaces for archiving and interactive work; specification of metadata and data classification rules for subsequent interactive interpretation by involving the user groups**

Literature and recommendations on international metadata standards were gathered and put to the discussion: project and file level metadata for different prospection methods, ADS, ESRI and other international metadata recommendations were considered. An evaluation of the international standards for geodatabases is in progress. Especially the issue of the geodatabase design was considered, resulting in draft proposal for standards.

### **WP Definition of archiving strategy (hardware and workflow) and specification of data maintenance workflow. Specification of requirements and access rights of different user groups**

This WP has been prolonged and concentrates on two levels. On one hand, literature and international standards on archiving of prospection data were prepared for LBI ArchPro discussion: archive design, areas of responsibility, file formats, data set and report information etc. At the same time LBI ArchPro specification of data formats for every program line was made, data concept and data naming convention were discussed and the LBI ArchPro data server was set up.

### **WP Definition of research-wiki and implementation as GIS-extension**

The definition of a research-wiki was set forward to the first months, because a need for easy accessible documentation of different research tasks was recognized soon. The LBI ArchPro team has discussed different Open Source wikis as well as commercial wikis. The decision in favour of the wiki of University Vienna (Software Confluence) was taken soon. During the process of building up the wiki, possible future use through partners was discussed with ZID Uni Vienna.

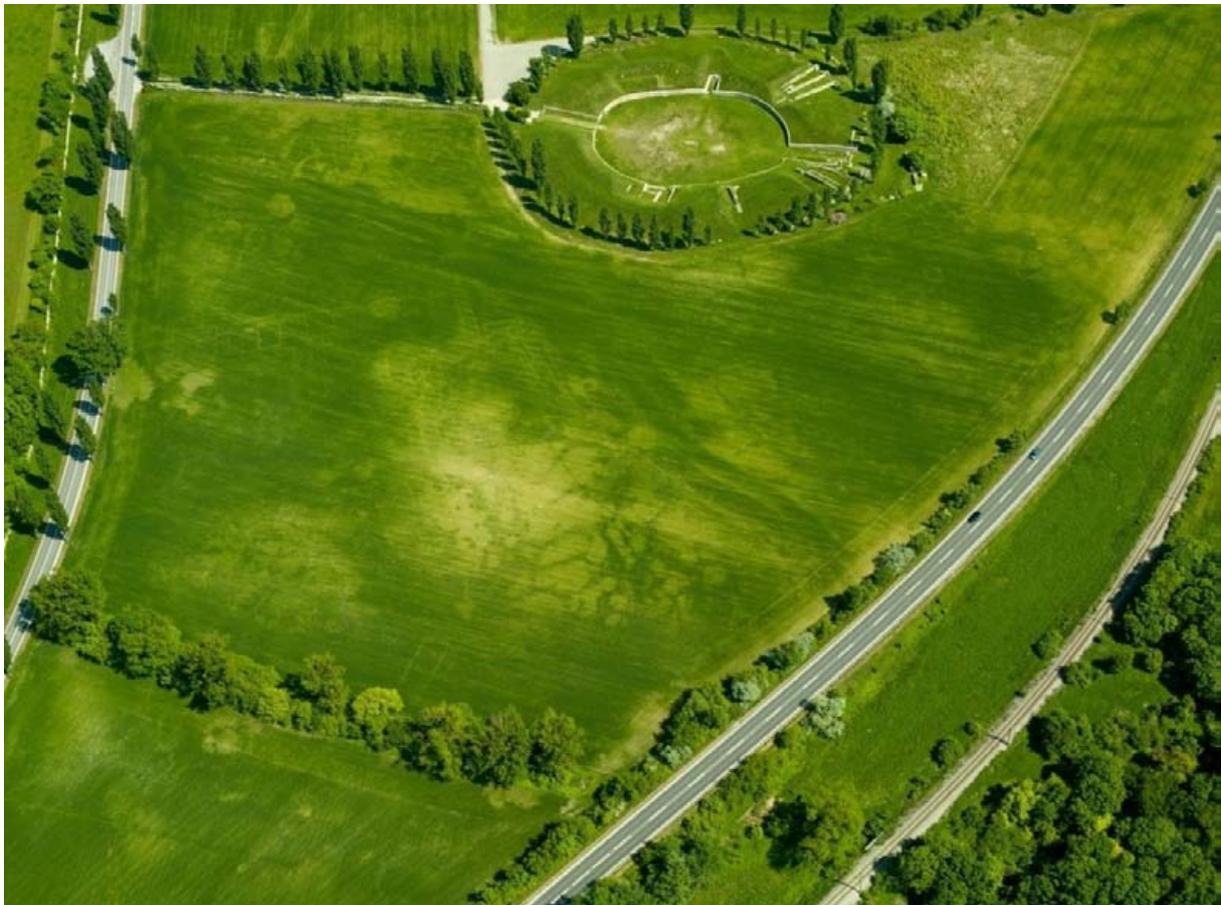
### **WP Definition of workflow for integrated archaeological interpretation of prospection data based on the analysis of experts approaches**

This WP has been prolonged. Literature and international recommendations on interpretation workflow have been put to the discussion: Project and data documentation, interpretation, images and reports. Workflow in LBI ArchPro remote sensing and geophysical prospection is in discussion.

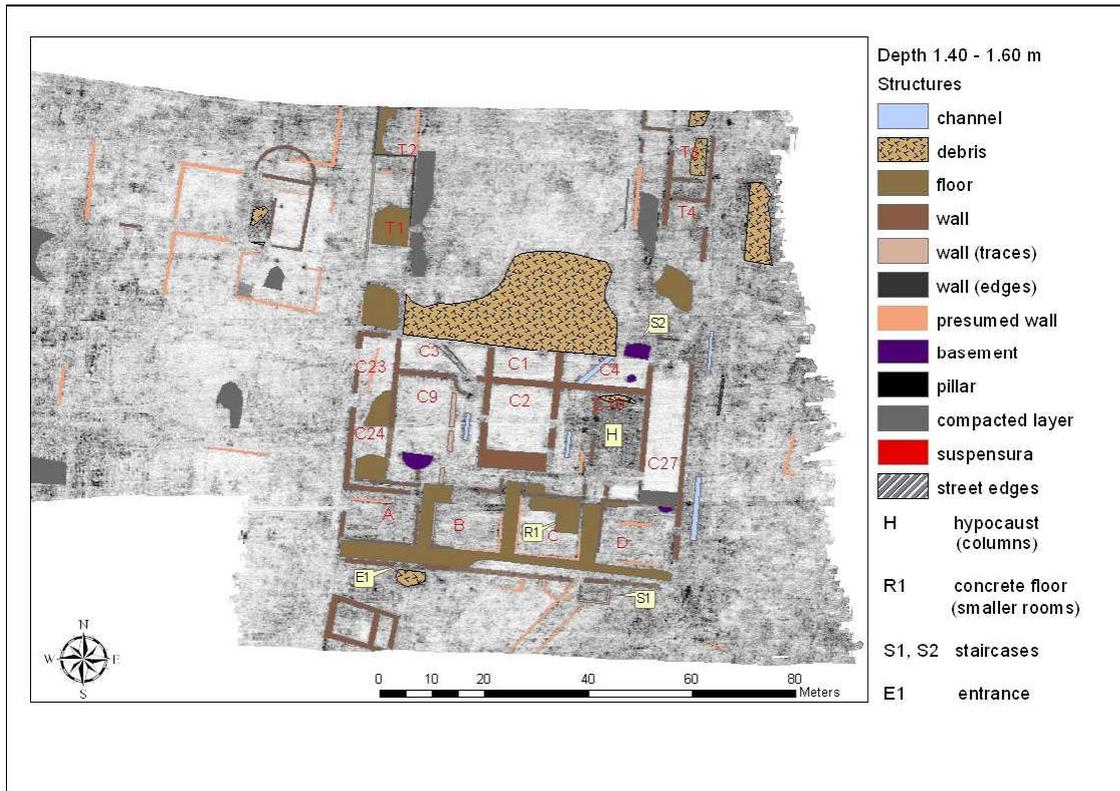
### **WP Integrated archaeological interpretation of data from the case studies**

A change of timetable for this WP was decided. Newly gained prospection data from international case studies have been processed and their interpretation is work in progress. For Austrian case studies the interpretation work has also started with some of existing and new data sets.

A series of reconnaissance flights was made over the Austrian case study areas. The new relevant aerial photographs of the case study areas Carnuntum were rectified revealing for the first time deep detail of the legionary camp; also the *Ludus* could be seen first time from aerial photographs.



GPR data collected in the year 2011 in the area of the Carnuntum Forum by using the MIRA multi channel system equipped with 400 Mhz antennas was analyzed. The prospected area of about 18.000 m<sup>2</sup> corresponds to the southern and central part (square) of the Forum and also includes an area west of the Forum where other structures of the roman town can be detected.

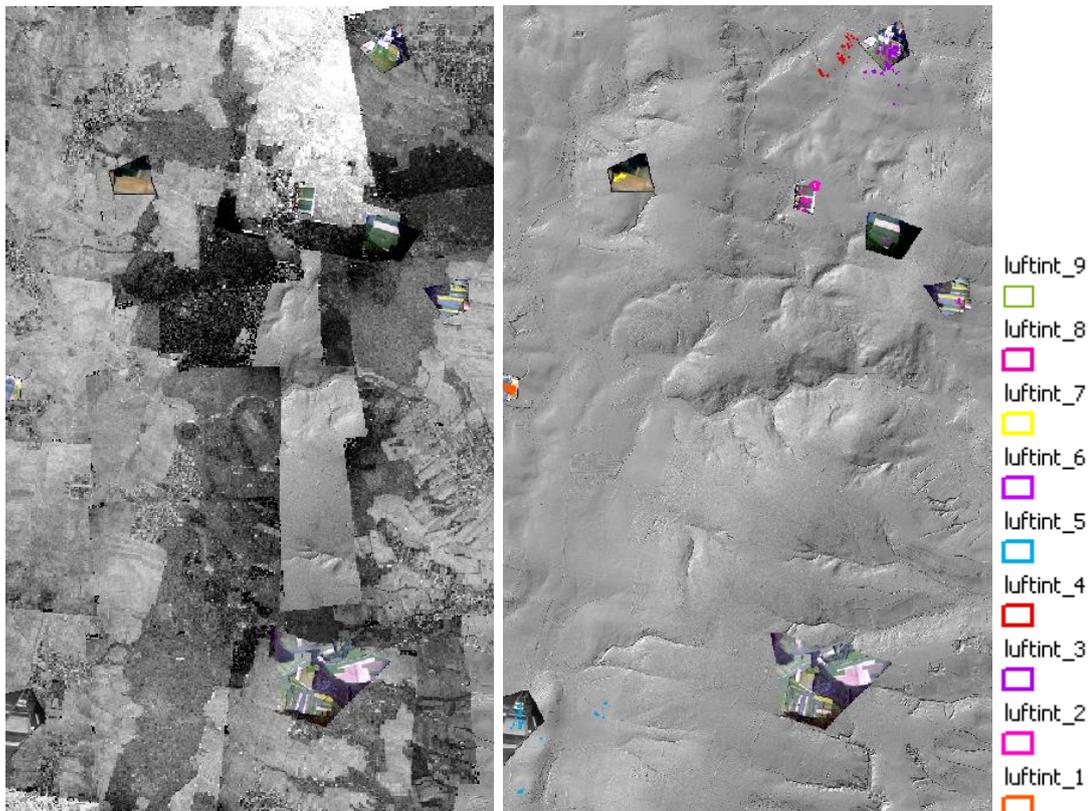


The reconnaissance flights over Kreuttal revealed several new sites. The aerial shows several Grubenhäuser, so far undated. Also in the upper right area – close to the forest – ditch-like features can be seen, which could be part of a middle Neolithic Kreisgrabenanlage.

Interpretation of data from case study Kreuttal was focusing on finding, digitizing and interpretation archaeological sites. In order to fulfill this objective a data set has been prepared:

- a group of 63 orthophotos – 53 are created from vertical images (22 from March 1981; 15 from July 1992; 16 from March 2010) and 10 from oblique images (1 from June 1997; 1 from Mai 2000, 1 from June 2000; 7 from June 2010). The orthophotos cover almost the whole part of the study area Kreuttal,
- a group of 50 bought orthophotos with GSD of 25 cm,
- terrain model with 1 meter grid size,
- data from magnetic prospection (as a support data).

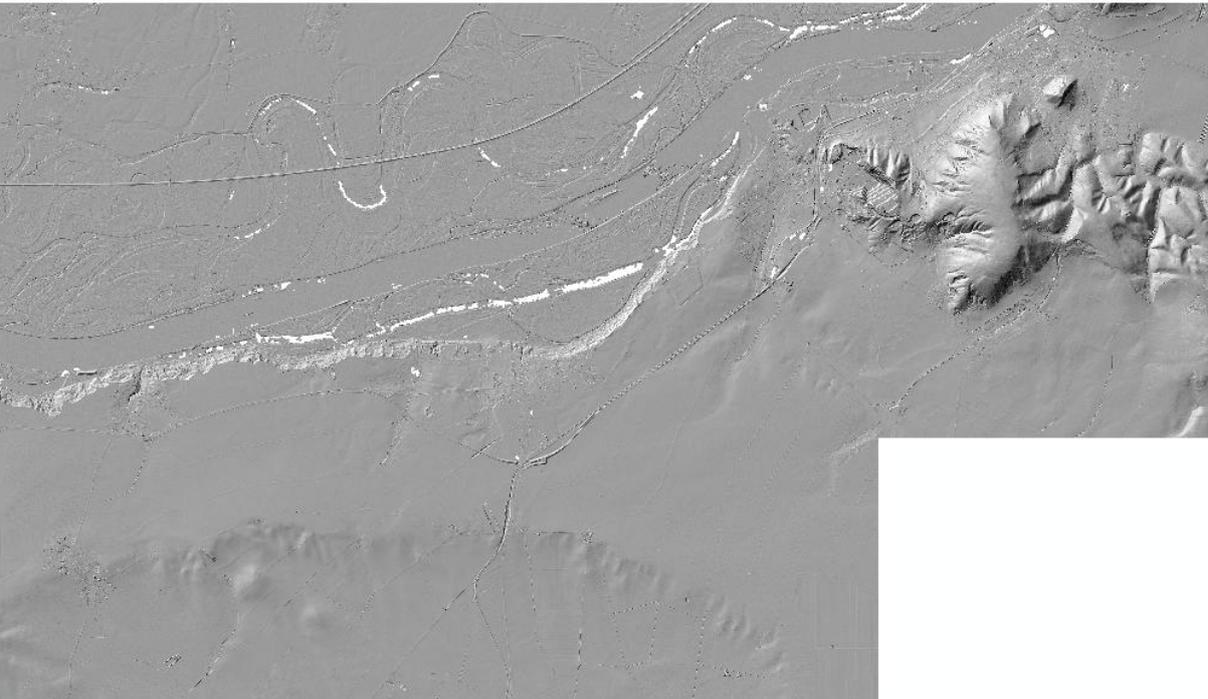
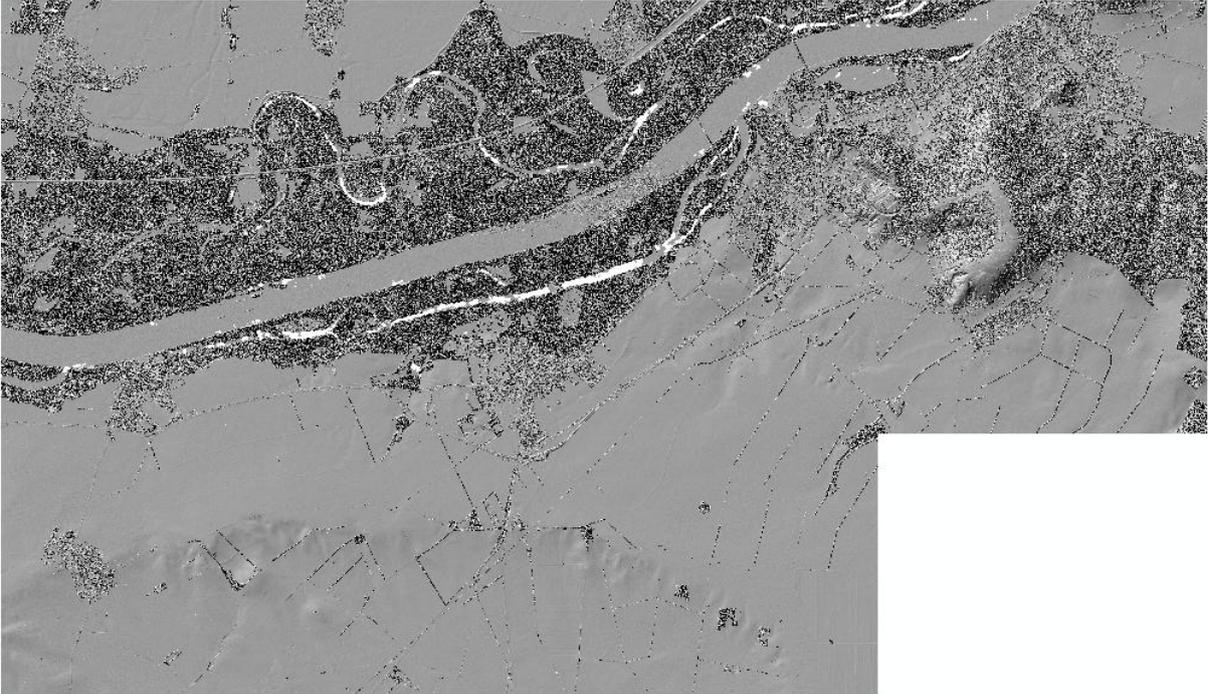
The entire data set has been imported to ArcGis. Currently nine new archaeological sites have been recognized and partly digitized. The archaeological interpretation was made till now for one of them. The work on this project is still in progress.



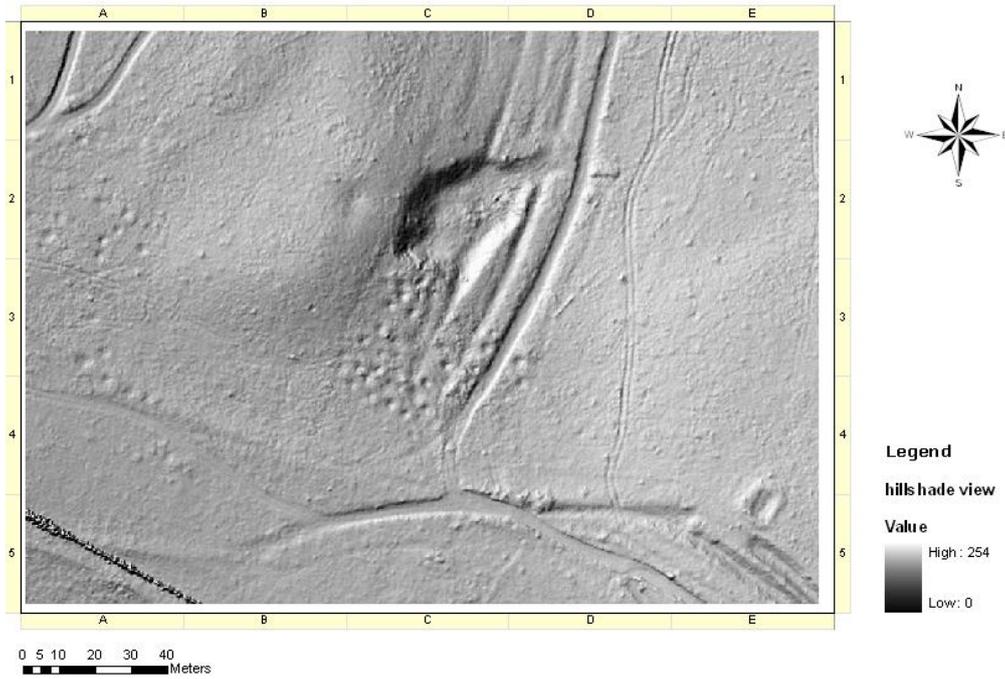
Left: Location of the orthophotos; Right: Location of newly recognized archaeological sites.

A mosaic for case study Carnuntum has been created in ArcMap software. The data to merge was: 121 \*.GRD (\*.ASC – ArcGis Ascii) files for DTM and the same amount of files for DSM. No filtering was used, data was just combined together. There was no problem with merging the DTM parts, but the DSM input data was probably exported incorrect what caused the presence of holes between tiles. To fill the voids a group of commands was used in ArcMap software.

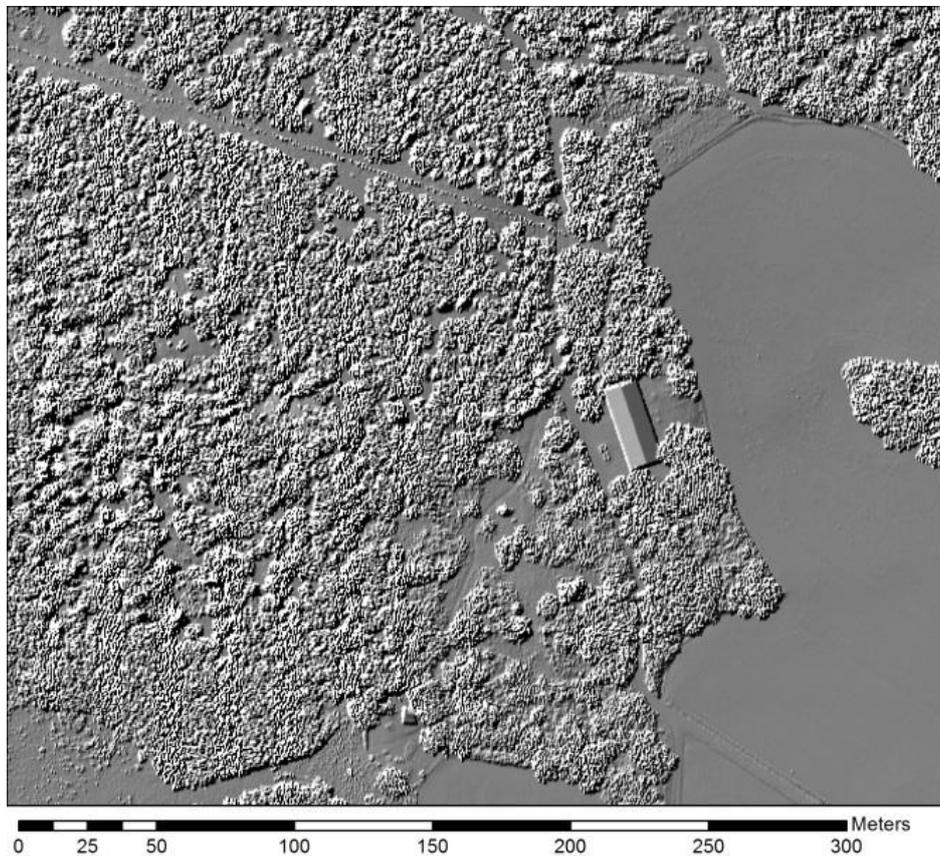
For the case study St. Anna a comparison of LiDAR filters was done - a DTM was derived manually from the ALS point cloud. This involved also a visit to the site for checking the results.

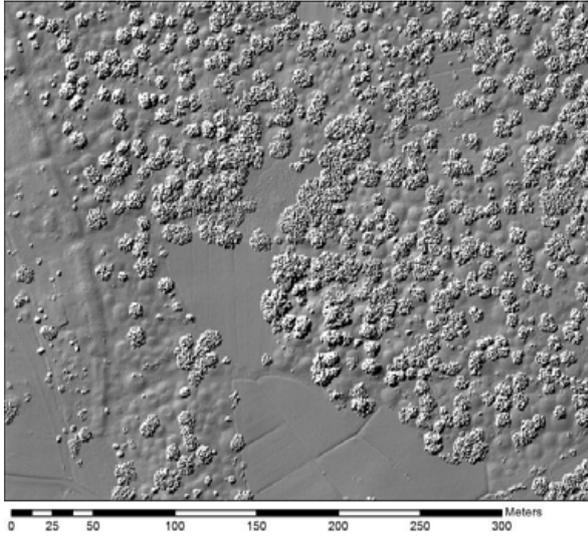


Test Area One - DACHSBAUTEN - Surface before the field control

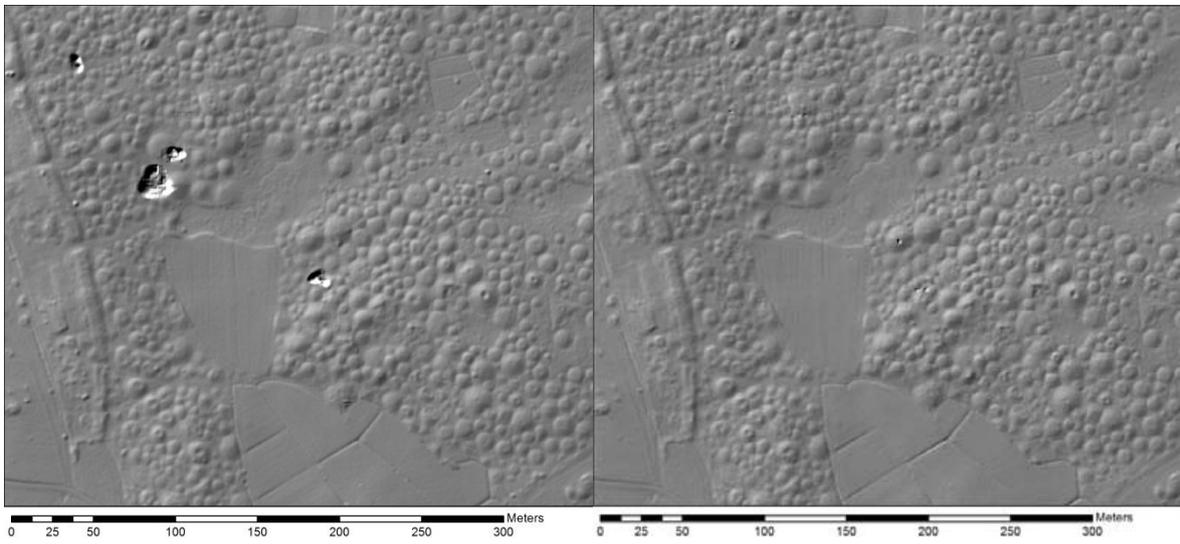


The case study Birka was scanned by partner ABT in November 2011. A filter was developed within the software package SCOP++, which was adapted to the topographic and environmental situation in Birka. A few test areas were chosen, to adapt the filter for a maximum on information after removing the vegetation. The results were satisfying and are depicted using three test areas.

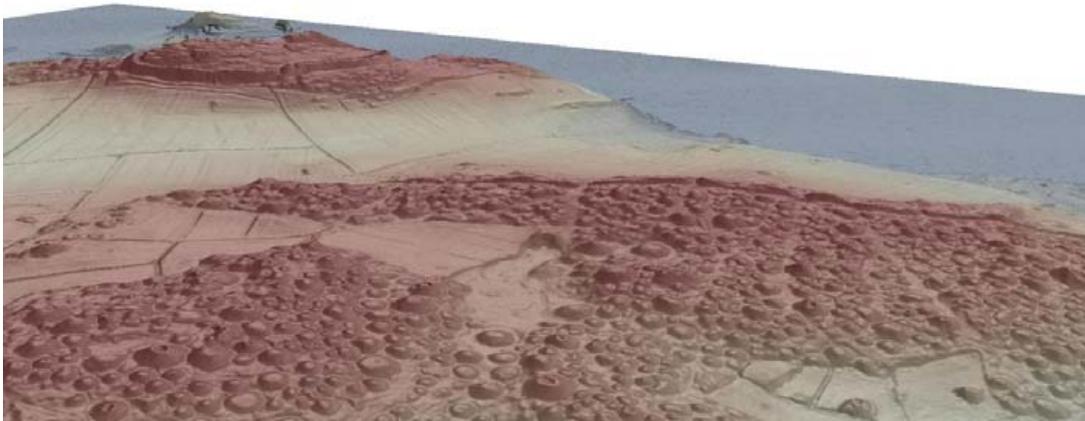




*DSM*



*Left: standard-filter; right: newly developed filter in SCOP++.*



## 4. CASE STUDIES

### Vestfold, N

From the 2<sup>nd</sup> to the 5<sup>th</sup> of May a LBI ArchPro team drove to Norway to work on the case study Larvik / Vestfold. Lars Gustavsen (NIKU) and Christer Tønning (VfK) completed the team.

The survey area was the site of Kaupang, probably Norway's first proto urban settlement. The site has been surveyed using geomagnetics and GPR during the first field campaign in 2010 but because of problems with the GPR equipment and data processing the results were not usable. Due to the important status of the site of Kaupang the survey was redone in 2011 to guarantee the highest quality.

The measurement parameters of the MIRA system had been changed to acquire data with the highest possible resolution and accuracy. The positioning problems in 2010 were caused by the use of the odometer wheel on the Kubota minitractor, in 2011 the GPR measurement was triggered with a constant time, measurements every 0.02 seconds (50Hz). This change helped to avoid any positioning errors and led to an in-line sample spacing of 3-4 cm (8 cm in 2010). The complete area of 6.2 ha was surveyed within three days of fieldwork. The first resulting images show building and harbor structures as they could be expected in a Viking age trading settlement. Changes in the survey equipment can also lead to better results using geomagnetics. As the GPR results have shown the highest resolution is absolutely necessary on a site like Kaupang.

During the time at Kaupang the LBI ArchPro team visited the excavations at Lunde which were carried out in the first week of May 2010. The huge field of cooking pits (730 pits) at Lunde was discovered during the LBI ArchPro field campaign in September 2010. The excavations carried out by Prof. Frode Iversen (Oslo University) in course of The Assembly Project had the goal to date the field of pits. Samples for susceptibility measurements were taken by the LBI ArchPro team to get a better understanding of the anomalies seen in the magnetics – over 2/3 of the pits were not visible in the magnetic measurement.

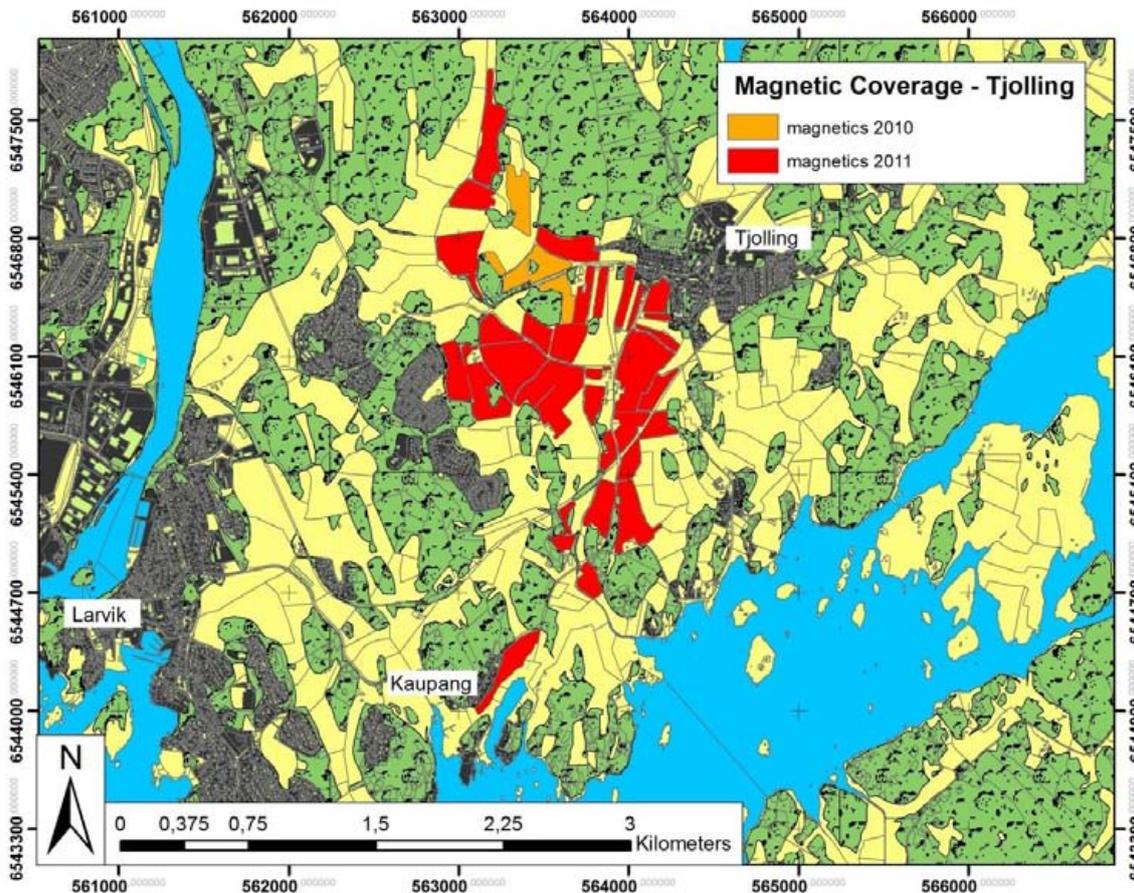
From September 10<sup>th</sup> until October 6<sup>th</sup> a LBI ArchPro team drove to Norway to work on the case study Larvik / Vestfold, where it was complemented by staff from the partner NIKU.

After testing the equipment under Norwegian conditions during the first campaign in 2010 the focus in 2011 was on conducting large scale surveys on areas around Tjøllingvollen and Berg. Two multichannel GPR systems (MIRA, SPIDAR) and one motorized magnetics-device (Förster PNC) were brought to Norway. The MIRA system was in use for two weeks before it was brought to Sweden for the case study Birka.

Due to a very rainy summer 2011 in Norway the survey conditions were in general unsatisfactory. Many fields were partly flooded and even the ATVs could not drive in some places. Especially the GPR surveys at the beginning of the campaign were affected by the adverse soil conditions.

The main survey area was around the modern village of Tjøllingvollen. Large-scale magnetic surveys were conducted in order to combine the previously measured areas at the archaeological site of Kaupang and the farmstead of Lunde. The area spans over 2.5 by 0.7 km and all accessible fields were meant to be surveyed using magnetometry during the 2011 fieldwork campaign. In total 108 hectares of magnetics were covered during 10 days of fieldwork. GPR survey areas were selected based on the magnetic survey results and on the interpretation of aerial images. Using the SPIDAR system 9.6 hectares were prospected, as well as 2.2 ha with the MIRA system.

The second survey area was located at Berg in close distance to the site of Aske, which was surveyed in 2010. Berg, a medieval church site, is situated in a former part of the Hummerbakkenfjord. Due to the post-glacial land uplift the valley bottom lies today approximately 6 to 8 m above current sea-level. Using magnetometry an area of 30 ha was surveyed in 2011, covering almost a complete section through the valley. Archaeological structures were detected along the dry flanks of the valley as well as in the former wetland at its bottom, possibly representing structural distinctions within this site. Circa 8.5 ha were surveyed using the GPR systems. The GPR areas were selected on basis of the results of the previous magnetic surveys. Due to the bad survey conditions only a few archaeological features visible in the magnetic data were confirmed by GPR. Through analysis of the available ALS data of the forested areas around Berg and following the geophysical surveys several new burial mounds were discovered and confirmed by subsequent field-walking.



## Birka, S

On May 21<sup>st</sup> 2011 the LBI ArchPro geophysical prospection team gathered in Uppsala where some of the prospection vehicles and hardware had remained with partner RAÄ-UV after the Kaupang survey (Vestfold Case Study) earlier that month. One quad bike was collected from storage at Uppåkra.

With the help of Lennart Nygren (RAÄ) the survey vehicles and equipment were shipped on Sunday 23<sup>rd</sup> onto the island of Björkö where the base was established in the Academy Villa. Geophysical archaeological prospection surveys with high-definition GPR (MALÅ Imaging Radar Array) and magnetometer measurements (motorized Eastern Atlas / Foerster 10 channel system) commenced on Monday. Wolfgang Neubauer and a second quad bike from RAÄ-UV were collected and brought onto the island.

A second, newly constructed stainless steel cart for the mount of the SPIDAR network GPR system was mounted and the entire system was intensively tested. Unreliable behaviour of the commercial data collection software rendered the system impractical for large scale application. Steps to resolve the issues in collaboration with the system manufacturer were taken.

Magnetic susceptibility measurements were made with a handheld device (SM-30 kappameter) on selected rocks, outcrops and the soil. Places of possible archaeological prospection interest in the area of the grave field Hemlanden and on the southern part of the island Grönsö were inspected.

Contact with the local landowners was established and the problem of disturbances caused by the geophysical survey to ground nesting birds during the breeding season, as well as ways to ameliorate any negative effects discussed. It was decided to maintain contact with the landowners regarding any future fieldwork – which subsequently in September 2011 resulted in a much improved situation and survey conditions.

The Swedish case study Birka-Hovgården is ideally suited for the integration of remote sensing (full waveform airborne laser scanning - ALS) archaeological prospection with high resolution geophysical archaeological prospection data. Due to the considerable topographic variation throughout the survey area, the presence of Sweden's largest field of grave mounds (approximately 3000) and other archaeological structures still visible in

the topography, and the postglacial land rise of approximately 6m since the year 750 AD, causing Viking Age harbours now to be located high up on dry land, possibilities for the funding and acquisition of ALS data were discussed and evaluated.

The case study greatly benefited from the kind support and hospitality of the islands manager (RAÄ) Lennart Nygren.

## **Uppåkra, S**

On Monday 11<sup>th</sup> and Tuesday 12<sup>th</sup> of April 2011 the survey team travelled by car to Uppåkra. A base for equipment storage was established in a farm hall kindly made available on site by the local farmer Staffan Dromberg.

Initially all affected landowners were visited for information and a detailed scheduling of the large-scale fieldwork. Due to the impending sowing and related preparation of the fields the time window for geophysical fieldwork was very limited. Professor Lars Larsson and the landowners were very understanding and supportive in this process. Weather and soil conditions were throughout the survey period very good.

According to field accessibility the survey areas were mapped using two motorized magnetometer systems consisting of Eastern Atlas 5 and 10 channel digitizers and corresponding Foerster gradiometer probes (65 cm) mounted on instrument carriers towed by quad bikes. The 10 channel system was operated with 9 available sensors with 25 cm crossline sensor spacing. For positioning JAVAD RTK-GPS rovers with a common base station were used. With increasing fieldwork routine considerable daily coverage rates became possible.

Two central areas covered with lawn in direct neighbourhood of Uppåkra church were mapped with the MALÅ Imaging Radar Array with 8 cm crossline and inline sample spacing, resulting in considerably improved data quality compared to a manual survey conducted in 2010 with 25 cm crossline spacing. All earlier in the data recognized structures were encountered, the resulting image quality and resolution was considerably improved, permitting more detailed data analysis and archaeological interpretation.

The central areas surrounding the topographic elevation on which Uppåkra church has been built were digitized in 3D using a Riegl LMS Z420i laser scanner mounted on a custom built tower and rig that was moved between scan positions with the Kubota tractor. Scanning methodology and technology were optimized.

The GPR data showed clear indications of a circular ring structure of circa 10 m diameter with a central rectangular, E-W oriented stone structure, as well as several large pits and traces of a prehistoric trackway/road underneath the lawn in front of Uppåkra churchyard. On request of the local archaeologists three areas were marked on the lawn in front of Uppåkra churchyard for archaeological excavation by Lund University under the supervision of Prof. Larsson, Bengt Söderberg and Birgitta Pilz-Williams.

After the end of the fieldwork Manuel Gabler studied for two more weeks material related to the site and analysed the data, with close support by the local partners.

## **Stonehenge, GB**

Stonehenge occupies one of the richest archaeological landscapes in the world, recorded in the course of intensive archaeological and antiquarian research over several hundred years, yet much of this landscape effectively remains terra incognita. This project aims to address gaps in our knowledge and understanding of the Stonehenge landscape by conducting a cutting-edge geophysical and remote sensing survey at an unprecedented scale. The results of the proposed work will be used to create a highly detailed archaeological map of the 'invisible' landscape, providing the basis for a full interpretative synthesis of all existing remote sensing and geophysical data from the study area. For the first time it will thus be possible to create total digital models of the Stonehenge landscape at a true 'landscape scale' that will not only transcend the immediate surrounds of individual monuments within the study area, but will also tie them together within a seamless map of sub-surface and surface archaeological features and structures.

From 1<sup>st</sup> to 22<sup>th</sup> July 2011 the second fieldwork campaign for the LBI ArchPro case study at Stonehenge has been carried out as part of the "Stonehenge Hidden Landscape Project" and was again directed by the British partner organization VISTA of the Institute of Archaeology and Antiquity at the University of Birmingham. As 2010 additional staff and students from the Universities of Bradford and Vienna joined the LBI ArchPro fieldwork team. A team of geophysicists of the UK Ministry of Defence kindly supported the project by conducting some large scale motorized magnetic surveys on MOD land. A first aim of this year's case study



campaign was the testing of two novel measurement devices: A new motorized 10 probe Foerster magnetometer system with three Foerster data loggers and CAN-Bus connection between loggers and field laptop and a reassembled hand driven 6 sensor caesium magnetometer system. Both systems have been tested successfully. The new Foerster system was used in collecting large datasets for the project – after coping with some initial problems with the CAN-Bus. The Caesium system has been used for field tests in the area of the henge monument G50 discovered in 2010, testing various configurations of the used caesium sensors. Additionally the system has been used for collecting high resolution reference data in an area of 3 hectares surrounding the Avenue and other parts of this year's campaign zone.

Furthermore, the large-scale collection of high-resolution survey data in the north-eastern and eastern parts of the survey area has been the second goal of the campaign. In addition to this survey the sections of the 2010 campaign area which have not been able to be surveyed last year have been covered this year.

In 2011 at Stonehenge the MIRA system was used to cover an area of about 33 ha with an unmatched spatial resolution. The MIRA system worked without any malfunctions but a broken antenna box lead to some water beneath the antennas. The box had to be opened during the nights in order to dry the antennas.

Enduring hardware problems with the SPIDAR system – a problem existing since the first campaign in Stonehenge – could not be solved. The SPIDAR system could therefore only be used for some hardware tests at Stonehenge.

Single channel GPR measurements were used to survey some large burial mounds by the VISTA team. Terrestrial laser scanning by the LBI ArchPro and its Partner VISTA of the Kings barrows and the landscape north of the A344 resulted in a highly detailed DTM of the area north of Stonehenge including the course of the Avenue and the Cursus.

This year's magnetometer measurements at Stonehenge featured far less problems than those of 2010. There existed some initial problems with the new Foerster system, especially the CAN-Bus connection was of insufficient durability in rough terrain. These problems could not be solved completely. The second magnetometer system with the EA-Logger worked almost without problems, even though some malfunctions of the power supply occurred. In 2011 some 210 hectares of area were surveyed with magnetometer prospection at Stonehenge.



## Stubersheimer Alb, D

The Stubersheimer Alb is part of the "Schwäbische Alb" in Baden Württemberg (southwest Germany). The case study area is based between and close around the three villages of Bräunisheim, Schalkstetten and Stubersheim and is an archaeologically well known area. The LBI ArchPro case study includes an area covering some 15 square kilometres and intensive archaeological prospection is planned using GPR, magnetics, LiDAR and aerial photography as well as classical field survey and soil analysis in form of phosphate measurements.

The field work is coordinated by RGZM, local cooperation partners are Baden-Württemberg's state department for the preservation of monuments and the regional council of Tübingen and Stuttgart (state department for the preservation of monuments) as well as affected municipalities. The major focus of the case study Stubersheimer Alb is an exemplary analysis of the temporal and spatial transformation of an entire landscape and the eco-historical as well as a human ecological interpretation. In the long term the case study will be included into a number of comparative studies conducted throughout Europe.

The test area is archaeologically well known and shows a broad variety of rural usage. The area was chosen to explore and test the full potential of the developed prospection methods within an exclusively agriculturally used landscape. The complete mapping of the entire area will be one of the goals over the next three years, providing the basis for further archaeological research and interpretation of the sites and their relation in this specific landscape.

The campaign in Stubersheim started in April 2011 with estimated three weeks and the main LBI ArchPro equipment comprised of two Fluxgate systems (5 and 10 sensors due to the EA data-loggers) and the GPR Mala/Mira-system. Due to bad weather conditions and sometimes difficult negotiations with land- owners it was only possible to measure on 7 days. Still more than 1,2 km<sup>2</sup> could be surveyed and brought some unexpected results.

The analysis of the first prospection data acquired in April 2011 shows a surprisingly dense settlement in the Roman cultural landscape. Near Bräunisheim two Roman estates were found and mapped with magnetic and GPS surveys, imaging the structures in great architectural detail. One of the Villa Rusticae shows a patio surrounded by a row of columns, as well as parts of the bath. Next to one of the estates additional structures were detected, possibly representing parts of grave monuments. Near the well-known Roman road between Castell Urspring and Heidenheim details of a wooden settlement surrounded by palisades and a ditch were found. It is possible that some of the newly detected structures are caused by remains of the 1225 mentioned, and sought after hamlet of *Wolfgerswilar*.



## **Carnuntum, A**

In autumn 2011 the field to the west of the civil amphitheatre of Carnuntum, in which the school of gladiators had been discovered earlier, has been surveyed in detail using high-resolution ground penetrating radar with the 16 channel MIRA system as well as using a 10 channel motorized Foerster gradiometer magnetometry. Building structures and graves were mapped in great detail.

In collaboration with the LBI ArchPro a team from the department of soil sciences at Ghent University successfully demonstrated the use of a novel electromagnetic device (Dualem) at the site of the school of gladiators.

Additionally, over the course of two days a field west of the Vicus, where a Roman aqueduct was assumed to have accidentally been encountered by the land owner, was surveyed with the MIRA GPR system.



## **Kreuttal, A**

From the 9<sup>th</sup> to the 27<sup>th</sup> of May 2011 an excavation organized by VIAS and the LBI ArchPro was arranged at the Ochsenberg/Kreuzstetten in Lower Austria. The excavation was conducted as an educational class for students of pre- and early history with a special focus on the method of stratigraphic excavation and documentation. A new method for the 3D documentation of surfaces (top and bottom surface of stratigraphic units) recently introduced and tested by the LBI ArchPro team was developed, namely the photogrammetric documentation using a digital SLR and the software *Photoscan*. Therefore the benefit of this excavation for the LBI ArchPro was mainly the possibility to compare soil samples with the geomagnetic values and to test new photogrammetric approaches to 3D-surface documentation. It formed also the basis of a soil sampling survey together with Rod Salisbury, University of Leicester in July and August. Additionally a geomagnetic survey was carried out in April 2011 to specify the later area of the excavation. During the excavation process several cores and samples for susceptibility measurements were taken. For this purpose R. Salisbury was invited to give some guidelines and to work on an overall sampling, analysing and documentation process of soil samples. The aim of these investigations was to get a better understanding of the geomagnetic prospected values.

On several days in July and August a soil sampling survey was carried out with an aim to test soil sampling as a complementary method to other LBI ArchPro prospecting methods. Mainly questions of accumulation and erosion processes (also documented through the survey) should be worked out and tested. For this purpose several areas within the northern part of the case study were chosen: along the Russbach River, which is flowing through the Kreuttal itself and nearby the Kreisgrabenanlagen of Hornsburg. For the reconstruction of paleoenvironment, humid soils like along the Russbach are of interest, because of the chance of monitoring pollen profiles. Close to the Kreisgrabenanlage Hornsburg 2 soil samples were taken to analyse the amount of phosphates for monitoring human activity zones. Different approaches were discussed and tested to implement soil sampling into the prospecting methods used by the LBI ArchPro. Therefore a future project might include paleoenvironmental reconstruction based upon pollen profiling, declaring human activity zones by analysing phosphates for cores, eventually dating cores in using OLS or Radiocarbon dating to get information of time sequences, investigations of erosion and accumulation processes and the study of colluvium structures.

From August 19<sup>th</sup> to September 7<sup>th</sup> 2011 geomagnetic prospection was conducted in Hornsburg and Kreuzstetten area. In the beginning the motorized Eastern Atlas system with 10 Förster-Sensors was tested and used. It was the aim to improve the used technology, software and hardware and to work on a satisfying working procedure. On the other hand it was also of main interest to collect data from areas formerly measured with a system using Caesium magnetometers. This dataset will form the basis for comparative investigations of the used systems for further improvement of accuracy. The hugest connected area prospected was at the site of the Kreisgrabenanlage Hornsburg 1. Finally a second motorized system was set up, namely also using 10 Förster Sensors but another digitizer (Förster) and another synchronisation method for arranging magnetic and GPS values. With the second system – running short of time – an area of approx. 2 ha was prospected. The Kreuttal prospecting survey of August/September 2011 covered an overall area of 75ha mainly using one operating system.

## **Halbturn, A**

Between November 14<sup>th</sup> and December 14<sup>th</sup> 2011 the first geophysical prospection season for the Case Study Halbturn was conducted. The fieldwork campaign focused on large-scale magnetic prospection with a motorized 10 channel Eastern Atlas/Foerster gradiometer array; high-definition GPR prospection using the MIRA system was applied on selected areas. The SPIDAR multichannel network GPR was shortly tested but did not perform satisfactorily.

An area of approximately 2 km<sup>2</sup> was surveyed. The first analysis of the data shows extremely dense settlement activities. Next to already known structures (two villae rusticae and graveyard Halbturn I) completely new settlement structures (ditch systems, pits, sunken huts and small cremation graveyard) were detected. Further archaeological interpretation of the results will show to what extent this new archaeological features can be dated in Roman period. Prehistoric finds from systematic fieldwalking (1992 and 1994) point to Bronze and Iron Age settlement in the same area.

## 5. PUBLICATIONS AND REPORTS

Next to scientific publishing and participation on conferences review work for several journals (JAS, Archaeological Prospection, ISPRS J, IEEE, PERS, etc.), various conferences was done and international Scientific Committees (CIPA and AARG) was done.

## 6. PRESENTATIONS AND ACTIVE PARTICIPATION AT CONFERENCES

**Archéométrie 2011 - XVIIIe colloque du GMPCA, Centre Européen d'Archéométrie, 11.-15.04.2011, Luik, Belgium**

POSTER - Archaeological Computer Vision. GEERT VERHOEVEN

**31<sup>th</sup> EARSeL Meeting. 30.05 – 02.06.2011, Prague, Czech Republic**

LECTURE - Towards Archaeologically Relevant Hyperspectral Sampling (Verhoeven, G., Doneus, M., Briese, C.)  
GEERT VERHOEVEN

LECTURE - Taking Computer Vision Aloft. (Verhoeven, G., Doneus, M., Briese, C.) GEERT VERHOEVEN

**EARSeL 7th SIG-Imaging Spectroscopy Workshop, University of Edinburgh, Edinburgh, Scotland, 11.-13.04.2011**

POSTER - Towards Archaeologically Interesting Hyperspectral Sampling (Verhoeven, Doneus). GEERT VERHOEVEN

**Flights into the Past. Use of remote sensing in researching the past, Ljubljana, 12.05.2011.**

LECTURE - Airborne remote sensing in agricultural and forested landscapes (Doneus M., Fera M., Briese Ch.).  
MICHAEL DONEUS

**„Airborne LiDAR – Technology and Applications“. Summer School, University of Siena & B. Kessler Foundation, 29.-30.08.2011, Grosseto, Italy**

LECTURE - 3D Modeling in Archaeology & Cultural Heritage (M. Doneus). MICHAEL DONEUS

LECTURE - 3D recording and interpretation of archaeological excavations“ (W. Neubauer, M. Doneus). MICHAEL DONEUS

**Computer Applications in Archaeology (CAA), 10.-11.11.2011, Uppsala, Sweden**

LECTURE - Large-scale archaeological prospection of the Iron and Viking Age site Uppåkra in Sweden – First results of the LBI ArchPro landscape archaeological case study (Anders Biwall, Manuel Gabler, Alois Hinterleitner, Pär Karlsson, Matthias Kucera, Lars Larsson, Klaus Löcker, Erich Nau, Wolfgang Neubauer, Daniel Scherzer, Håkan Thorén, Immo Trinks, Mario Wallner, Thomas Zitz). IMMO TRINKS

LECTURE - Arkeologisk prospektering med georadar och magnetometer i Gamla Uppsala (I. Trinks, A. Biwall).  
IMMO TRINKS

LECTURE - Terrestrial laser scanning for the generation of a digital terrain model of the Iron and Viking Age site Uppåkra in Sweden (Anders Biwall, Manuel Gabler, Alois Hinterleitner, Pär Karlsson, Matthias Kucera, Lars Larsson, Klaus Löcker, Erich Nau, Wolfgang Neubauer, Daniel Scherzer, Håkan Thorén, Immo Trinks, Mario Wallner, Thomas Zitz). IMMO TRINKS

LECTURE - Professional geophysical archaeological prospection in Sweden and Norway (I. Trinks, A. Biwall).  
IMMO TRINKS

**Conference on Archaeological Prospection in Germany 2011. Mainz, Deutschland, 09.-10.09.2011 (KK).**

LECTURE – Case study Stubersheim (Kastovsky et al.) KAROLIN KASTOWSKY-PRIGLINGER

**XXIII<sup>rd</sup> International CIPA Symposium, Czech Technical University Prague 12.-16. 09.2011, Prague, Czech Republic.**

LECTURE - From Deposit to Pointcloud. A Study of Low-Cost Computer Vision Approaches for the Straightforward Documentation of Archaeological Excavations“ (Doneus M., Verhoeven G., Fera M., Briese C., Kucera M., Neubauer W). MICHEL DONEUS

**9<sup>th</sup> International Conference on Archaeological Prospection. Izmir, Türkei 19.-24.09.2011 (IT, KL)**

LECTURE - Advancing archaeological airborne remote sensing (Doneus M., Neubauer W., Verhoeven G., Briese). IMMO TRINKS

POSTER - The new Ludwig Boltzmann Institute for archaeological prospection & virtual archaeology (Briese C., Doneus M., Doneus N., Gabler M., Hinterleitner A., Kastowsky K., Klimczyk A., Kucera M., Löcker K., Nau E., Neubauer W., Poscetti V., Scherzer D., Trinks I., Wallner M., Verhoeven G., Zitz T.).

**AMBITIONS AND REALITIES Remote Sensing for Archaeology, Research and Conservation. Joint Meeting of the Aerial Archaeology Research Group (AARG) and European Association of Remote Sensing Laboratories (EARSel), under the auspices of UNESCO. Institute of Prehistory, Adam Mickiewicz University Poznan, 21.-24.09. 2011 (MD, GV, AK)**

LECTURE - Towards an advanced DTM generation in wooded areas for archaeological prospection (M. Doneus, C. Briese, A. Klimczyk and G. Verhoeven). MICHAEL DONEUS

LECTURE - Mapping by matching - A computer vision-based approach to fast and accurate georeferencing of archaeological aerial photographs (G. Verhoeven, M. Doneus, Ch. Briese). GEERT VERHOEVEN

**16<sup>th</sup> International Conference on Cultural Heritage and New Technologies. Wien, 14-16.11.2011 (MD, MN, AK)**

LECTURE - Archaeological Airborne Remote Sensing in Roman Carnuntum (M. Doneus, C. Gugl, G. Verhoeven). MICHAEL DONEUS

LECTURE - From Deposit to Pointcloud. A Study of Low-Cost Computer Vision Approaches for the Straightforward Documentation of Archaeological Excavations" (Doneus M., Verhoeven G., Fera M., Briese C., Kucera M., Neubauer W). MICHAEL DONEUS

LECTURE - Scheiblauber C., Pregesbauer M. Consolidated Visualization of Enormous 3D Scan Point Clouds with Scanopy, Conference on Cultural Heritage and New Technologies, Vienna. CLAUD SCHEIBLAUER

**UAV-g 2011 - Unmanned Aerial Vehicle in Geomatics. Zürich, 14-16 September 2011 at ETH Zurich (CB)**

Christian Briese attended the UAV-g conference in Zürich in order to update current UAV data acquisition and processing strategies.

**University Workshop "Full Waveform Airborne Laser Scanning for Vegetation Analysis", 22-23 September 2011, TU Wien (CB)**

LECTURE - Full waveform data processing and radiometric calibration (CHRISTIAN BRIESE)

Practical Demonstration: Derivation of topographic models (C. Briese, M. Hollaus)

Practical Demonstration: Analysis of full waveform information (C. Briese, A. Roncat, W. Mücke)

## **Other lectures**

Schweiz – Zürich. Möglichkeiten und Grenzen des flugzeuggetragenen Laserscannings (LiDAR) in der archäologischen Prospektion. Universität Zürich, Inst. F. Ur- und Frühgeschichte. Michael Doneus

Österreich – Purbach. Der Blick in die Vergangenheit - archäologische Prospektion aus der Luft. Festvortrag des historischen Vereins in Purbach. Michael Doneus

Österreich – Wien. "Neue Methoden in der Landschaftsarchäologie". Vortrag am Institut für Umweltgeschichte, Universität Klagenfurt. Michael Doneus

## OTHER ACTIVITIES

### 1. SCIENTIFIC COOPERATION & THIRD PARTY FOUNDED PROJECTS

#### **Meeting LBI ArchPro - Ghent University**

Wolfgang Neubauer and Geert Verhoeven had a meeting on 12<sup>th</sup> September with soil scientists from Ghent University (Marc Van Meirvenne and Timothy Saey) that are specialized in EMI. In the meeting, it was decided that the Ghent team would do a detailed EMI prospection of the ludus area. In October, this survey was completed and the impressive results presented in Vienna in December. Plans for further collaboration were created.

#### **Meeting LBI ArchPro - NIKU, Oslo**

Christian Briese and Michael Doneus have attended from 04. till 06. July the LIDAR meeting in Oslo. Future research work based on the existing Larvik data was discussed and fixed. First further tests on the available discrete echo Larvik data were performed.

### 2. LBI ARCHPRO WORKSHOPS AND CONFERENCES

#### **1<sup>st</sup> trans-disciplinary workshop on Agents in Archaeology**

3<sup>rd</sup> - 4<sup>th</sup> March 2011, Vienna

Cooperation: Museum of Natural History, Vienna and TU-Wien, LBI ArchPro, UFG Wien

##### 03.03.2011: Theorie-Modul

09:15-10:00 Agentbased Simulations in Archaeology – State of the Art (Mag. Kerstin Kowarik, AG Wien/NHM Wien)

10:00-10:45 Simulations – theoretical considerations (Dipl.Ing. Nikolas Popper, TU Wien)

11:00-11:30 The Manzikert-Project (Dr. Georgios Theodoropoulos, University of Birmingham)

11:30-12:00 GIS-Applications in Archaeology (Dr. Mark Lake, University College London)

12:00-12:30 Digital methods in Archaeology (Dr. Michael Doneus, Universität Wien)

##### 03.03.2011: Praxis-Modul 1

13:30-14:45 Einführung in NetLogo (Dipl.Ing. Gabriel Wurzer, TU Wien)

15:00-18:00 NetLogo Programmieren (Dipl.Ing. Gabriel Wurzer, TU Wien)

##### 04.03.2011: Praxis-Modul 2

09:00-12:30 Modellierungsübung (Dipl.Ing. Gabriel Wurzer, Mag. Kerstin Kowarik, Mag. Hans Reschreiter, Dr. Michael Doneus)

13:30-15:30 Modell-Implementierung (Dipl.Ing. Gabriel Wurzer)

16:00-18:00 Analyse und Diskussion der Resultate (Dipl.Ing. Gabriel Wurzer, Mag. Kerstin Kowarik, Mag. Hans Reschreiter, Dr. Michael Doneus)

LECTURE - Archaeological Landscapes and Rational Agents. MICHAEL DONEUS

#### ***LBI ArchPro Workshop "Airborne Remote Sensing: State-of-Art"***

18<sup>th</sup> - 19<sup>th</sup> March 2011, Mannersdorf/Leithagebirge, Austria

The aim of the workshop was to show our state-of-art in airborne remote sensing, to share our advances with our partners and to discuss future applications and co-operations. Therefore, all partners of the LBI ArchPro were invited to a Workshop, which was held 17<sup>th</sup>-20<sup>th</sup> March 2011 in one of our case study areas (St. Anna) near Vienna. Several partners (NOEL, NIKU, RAÄ, TU-Wien, UFG, VIAS, and ZAMG) followed our invitation and had a successful meeting.

Topics of discussion: What do we currently consider the biggest hurdles for using the technology? What would the partners like to see changed to current-day practice? What do you expect from the technology? In how far would the partners like to actively co-operate?

<b>Friday, 18 March 2011 – 11.00 – 17.00</b>		
Michael Doneus	Introduction: Airborne Remote Sensing at the LBI	20
Michael Pregeßbauer	An Introduction to NÖ-GIS	20
Christian Briese, Michael Doneus	Full-waveform ALS for an advanced DTM generation in wooded areas for archaeological prospection	80
Agata Klimczyk	Evaluation of the ALS post-processing software, in terms of archaeologist's needs	25
Ole Risbøl	Airborne laser scanning for archaeological prospection in Norway - state-of-the-art and future directions	45
Michael Doneus	Aerial archaeology in Austria – state-of-art and prospects	25
Geert Verhoeven	Airborne hyperspectral scanning for archaeology: balancing between spatial details, radiometric noise and spectral accuracy	45
Håkan Thoren	Presentation of Birka	10
<b>Saturday, 19 March 2011 – 09.30 – 12.30</b>		
Christian Briese	Radiometric calibration of ALS data for archaeological prospection	30
Geert Verhoeven	Beyond Conventional Boundaries. New Low-cost Technologies and Methodologies for the Benefit of Aerial Archaeological Data Acquisition and Analysis	45
Christian Briese	Quadrocopter Presentation	45
Michael Doneus	St. Anna in der Wüste – Introduction to the case study area	30

## **Pioneering Archaeological Prospection Conference 2011**

October 9<sup>th</sup> - 12<sup>th</sup> 2011, Laa an der Thaya, Austria

In October 2011 the LBI ArchPro organized the first International Conference and Workshop on "Pioneering Archaeological Prospection". Focusing on the very beginnings in archaeological prospection to the absolute state-of-the-art, the LBI ArchPro managed to get together some of the finest specialists working in the field of archaeological prospection such as Martin Aitken, Mike Tite, Albert Hesse, John C. Belshé, Otto Braasch and Yasushi Nishimura as well as the 'new' generation of scientists including Jörg Fassbinder, Michel Dabas, Chris Gaffney, Vince Gaffney, Dominik Powlesland and the experts of the LBI ArchPro. Due to the great success and large attendance following events are being planned and will be published on the website.



### **Initiative College for Archaeological Prospection - IC-ArchPro**

In April 2010 the LBI ArchPro was involved in the successful submission of a proposal to establish an Initiative College for Archaeological Prospection IC-ArchPro. The 10 young researchers to be employed in this college will to a great extent work with and for the LBI ArchPro researchers on various research relevant topics.

#### **IC-ArchPro Workshop 1 “Airborne Remote Sensing”**

28<sup>th</sup>- 30<sup>th</sup> November 2011, Vienna

Organization Committee: Michael Doneus (University of Vienna), Wolfgang Lenhardt (ZAMG), Wolfgang Neubauer (LBI ArchPro), Wolfgang Kainz (University of Vienna), Erich Draganits (University of Vienna), Falko Daim (RGZM).

Altogether, the workshop had 30 Participants. All members of the IC-ArchPro and interested colleagues from the LBI ArchPro, ZAMG, University of Vienna, English Heritage and the DART project were present.

Monday, November 28 – Aerial Archaeology	
09.00 – 09.30	Welcome
09.30 – 11.00	Aerial Archaeology: Aims, History, Visibility Marks, Vertical – Oblique (MD)
11.00 – 11.30	Break
11.30 – 12.30	Air Photo Interpretation (PH, MD)
12.30 – 13.30	Lunch
13.30 – 14.30	Air Photo Interpretation (PH, MD)
14.30 – 15.00	Photogrammetry 1: Resolving the resolution issue: on pixels and spatial resolution (GV)
15.00 – 15.30	Break
15.30 – 17.00	Basics of Photogrammetry (CB)
Tuesday, November 29 – Aerial Archaeology / Airborne Laser Scanning	
09.00 – 09.30	Photogrammetry 2: where computer vision and photogrammetry meet: on the use of SFM in aerial archaeology (GV)
09.30 – 10.30	National Mapping Project (PH)
10.30 – 11.00	Break
11.00 – 12.30	Airborne Laser Scanning: Basics (CB)
12.30 – 13.30	Lunch
13.30 – 15.00	Airborne Laser Scanning: Archaeological Practice (MD)
15.00 – 15.30	Break
15.30 – 17.00	Airborne Laser Scanning and Landscape Archaeology (MD)

Wednesday, November 30 – AHS – Satellites	
09.00 – 10.30	Airborne Hyperspectral Scanning (CA)
10.30 – 11.00	Break
11.00 – 12.30	Airborne Hyperspectral Scanning (GV)
12.30 – 13.30	Lunch
13.30 – 15.00	Satellite Archaeology (AB)
15.00 – 15.30	Break
15.30 – 17.00	DART (AB)

### 3. TEACHING ACTIVITIES

#### Christian Briese

Summer 2011

TU Vienna

- 122.427 VO Topographische Modelle (several lectures)
- 122.428 UE Topographische Modelle

Winter 2011

TU Vienna

- 060116 VO Flugzeuggetragenes Laserscanning (LiDAR) für Archäologen (1 lecture)

Supported diploma and master thesis 2011

- Radiometric Calibration of Airborne Laser Scanner Data, H. Lehner
- Direkte Georeferenzierung von Bildern eines unbemannten Luftfahrzeuges mit LowCost-Sensoren, P. Glira
- UAV mapping, B. Bogensberger
- TLS georeferencing with tie spheres, B. Zeinzinger

#### Michael Doneus

Summer 2011

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060095 UE Vermessungskunde für Archäologen (mit Wolfgang Neubauer)
- 060113 VO Luftbild und Landschaftsarchäologie
- 060114 SE Methoden der Landschaftsarchäologie
- 060115 PV Privatissimum

Winter 2011

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060035 VO STEOP: BA VO aus: Grundlagen - Luftbildarchäologie
- 060101 SE Archäologische Prospektion (mit Wolfgang Neubauer)
- 060102 PV Privatissimum
- 060116 VO Flugzeuggetragenes Laserscanning (LiDAR) für Archäologen
- 060119 VU Luftbildarchäologische Interpretation
- 060120 UE GIS-Anwendungen in der Archäologie

## **Matthias Kucera**

Winter 2011

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060038 VO STEOP: BA VO aus: Grundlagen - Experimentellen Archäologie (mit Mathias Mehofer , Stefan Eichert , Karina Groemer , Hannes Herdits , Matthias Kucera , Franz Pieler , Johann Reschreiter , Ingrid Schierer
- 060041 VO STEOP: BA VO aus: Naturwissenschaftl. Methoden in der Archäologie - Geo- und Bioarchäologie (mit Gabriele Scharrer-Liska , Otto Cichocki , Erich Draganits , Matthias Kucera, Günther Karl Kunst , Ursula Thanheiser , Karin Wiltschke-Schrotta , Reinhard Zetter)

## **Immo Trinks**

Summer 2011

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060117 VU Magnetische und elektromagnetische Prospektion - Theorie und Praxis

Winter 2011

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060036 VO STEOP: BA VO aus: Grundlagen - Geophysikalische Prospektionsmethoden (mit Wolfgang Neubauer)
- 060080 VU Bodenradar - Theorie und Praxis
- 060114 VU Geophysikalische Prospektion

## **Wolfgang Neubauer**

Summer 2011

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060010 PV Privatissimum
- 060014 UE Stratigraphische Praxis
- 060095 UE Vermessungskunde für Archäologen (mit Michael Doneus)
- 060101 PR Praktikum Geophysikalische Prospektion
- 060128 LG Lehrgrabung 2, 4-wöchig

Winter 2011

Prehistory and Early History - Studies in Egyptology - Jewish Studies:

- 060036 VO STEOP: BA VO aus: Grundlagen - Geophysikalische Prospektionsmethoden (mit Immo Trinks)
- 060057 UE Grundlagen archäologischer Stratigraphie
- 060099 SV Ausgewählte Themen zur Wikingerzeit (mit Terje Gansum, Knut Paasche)
- 060100 PV Privatissimum
- 060101 SE Archäologische Prospektion (mit Michael Doneus)
- 060117 VO Stratigraphie und Archäologie
- 060118 SE GIS basierte Interpretation archäologischer Prospektionsdaten

## **4. OTHER**

LBI ArchPro - Team-Workshop Mauterndorf

Between February 28<sup>th</sup> and March 1<sup>st</sup> LBI ArchPro team workshop in Mauterndorf (Salzburg) took place. Workshop was moderated by VIP Consulting, Vienna.

## PUBLICATIONS

### 1. MONOGRAPHS

Doneus M. (in Press). Die hinterlassene Landschaft. Erkennen, Erklären und Verstehen in der Landschaftsarchäologie. Mitteilungen der Prähistorischen Kommission: Verlag ÖAW.

Doneus M., Gugl C., Doneus N. (in Press). Die Canabae von Carnuntum – ein Modell für römische Lagervorstädte? Von der Luftbildprospektion zur siedlungsarchäologischen Synthese: Verlag ÖAW

Doneus N. (Ed.) (in Press). Halbturn I. Das kaiserzeitliche Gräberfeld von Halbturn, Burgenland: Archäologie und Geschichte (Band 1), Intention, Abfall oder Zufall - naturwissenschaftliche Untersuchungen (Band 2). Monographien RGZM: Verlag RGZM.

### 2. PEER- REVIEWED PAPERS IN EDITED VOLUMES

Briese C., Glira, P., 2011 Reed mapping by unmanned aerial vehicles. International Symposium on Advanced Methods of Monitoring Reed Habitats in Europe, Rhombos-Verlag, 2011, 121 - 130.

Neubauer W., Doneus M., Trinks I., Verhoeven G., Eder-Hinterleitne, A., Seren S., Löcker K. (in Press). Long-term integrated archaeological prospection at the Roman Town of Carnuntum/Austria. Laurence Seminar Publication.

Roncat A., Lehner H., Briese C., 2011. Laser Pulse Variations and their Influence on Radiometric Calibration of Full-Waveform Laser Scanner Data. ISPRS Workshop Laser Scanning 2011, Calgary, Canada; 2011-08-29 - 2011-08-31; in: "Proceedings", ISPRS, Xxxviii / 5 / W12 (2011), ISSN: 1682-1777.

Verhoeven G. (in Press). Methods of Visualisation. In: Howell, G. M. E. & Vandenabeele, P. (eds.), Analytical Archaeometry. RSCPublishing.

Verhoeven G. (in Press). Rethinking the Spectrum – The Digital (R)Evolution in Archaeological Aerial Reconnaissance. Laurence Seminar Publication.

### 3. PEER-REVIEWED PAPERS IN JOURNALS

Bollmann E., Sailer R., Briese C., Stötter J., Fritzmann P. 2011: Potential of airborne laser scanning for geomorphologic feature and process detection and quantifications in high alpine mountains, Zeitschrift für Geomorphologie, 55 (2011), Suppl. 2; 86 - 104. IMPACT FACTOR: 0.477

Doneus M., Verhoeven G., Fera M., Briese C., Kucera M., Neubauer, W. 2011. From deposit to point cloud – A study of low-cost computer vision approaches for the straightforward documentation of archaeological excavations. Geoinformatics 6 (XXIIIrd International CIPA Symposium), 81–88. <http://geoinformatics.fsv.cvut.cz/pdf/geoinformatics-fce-ctu-2011-06.pdf>

Plets G., Gheyle W., Verhoeven G., De Reu J., Bourgeois J., Verhegge J., Stichelbaut B. (in Press). Towards a Three-Dimensional Registration of the Archaeological Heritage of the Altai Mountains. Antiquity. IMPACT FACTOR: 0.969

Verhoeven G., 2012. Near-InfraRed Aerial Crop Mark Archaeology: From Its Historical Use to Current Digital Implementations. *Journal of Archaeological Method and Theory* 19(1), 132-160. IMPACT Factor 1.097 (published online 2011).

Verhoeven G. 2011. Taking Computer Vision Aloft – Archaeological Three-dimensional Reconstructions from Aerial Photographs with PhotoScan. *Archaeological Prospection* 18(1), 67-73. IMPACT FACTOR: 1.368

Verhoeven G., Doneus, M. 2011. Balancing on the borderline – A low-cost approach to visualise the Red Edge shift for the benefit of aerial archaeology. *Archaeological Prospection* 18, 267-278. IMPACT FACTOR: 1.368

Verhoeven G., Doneus M., Briese C., Vermeulen F. (in Press). Mapping by matching - A computer vision-based approach to fast and accurate georeferencing of archaeological aerial photographs. *Journal of Archaeological Science*. IMPACT FACTOR: 1.710

Verhoeven G., Taelman D., Vermeulen F. 2011. Computer vision-based orthophoto mapping of complex archaeological sites: the ancient quarry of Pitaranha (Portugal-Spain). *Archaeometry*. Online published at <http://onlinelibrary.wiley.com/doi/10.1111/j.1475-4754.2012.00667.x/full>. IMPACT FACTOR: 1.581

#### 4. NON PEER-REVIEWED PAPERS

Briese C., Lehner H., Pfeifer N., Roncat A., Sailer R. 2011. Radiometric Calibration of Airborne Laser Scanning Data for the Analysis of Alpine Cryosphere and Periglacial Environment; Poster: Managing Alpine Future II, Innsbruck.

Briese C., Doneus M., Doneus N., Gabler M., Hinterleitner A., Kastowsky K., Klimczyk A., Kucera M., Löcker K., Nau E., Neubauer W., Poscetti V., Scherzer D., Trinks I., Wallner M., Verhoeven G., Zitz T., 2011. The new Ludwig Boltzmann Institute for archaeological prospection & virtual archaeology. In: Drahor, M. G., Berge M.A.: *Archaeological Prospection*. 9<sup>th</sup> International Conference on Archaeological Prospection. September 19-24, 2011 Izmir-Turkey, Archaeology and Art Publications, Istanbul 2011, 161-163.

Briese C., Pfennigbauer M., Lehner H., Ullrich A., Wagner W., Pfeifer N. (in Press). Radiometric Calibration Of Multi-Wavelength Airborne Laser Scanning Data, submitted paper to the ISPRS congress in Melbourne 2012.

Briese C., Zach G., Verhoeven G., Ullrich A., Doneus M. (in Press). Analysis Of Surface Models Generated By Terrestrial Laser Scanning Data And Multi-View Image Reconstruction, submitted abstract to the ISPRS congress in Melbourne 2012.

Doneus M. *Luftbildarchaologie im Hinterland des niederösterreichischen Limes* 2011. *Denkmalpflegebroschüre, Band 45, „Carnuntum und Limes“*, 27-29.

Doneus M., Briese C. 2011. Airborne Laser Scanning in Forested Areas - Potential and Limitations of an Archaeological Prospection Technique. In: Cowley D. C. (ed.) 2011, *Remote Sensing for Archaeological Heritage Management*, proceedings of an EAC Symposium, Reykjavik, Iceland, 25 –27 March 2010, EAC Occasional Paper No. 5, *Archaeolingua*.

Doneus M., Briese C., Klimczyk A., Verhoeven G. 2011. Towards an advanced DTM generation in wooded areas for archaeological prospection. In: *Ambitions and Realities. Remote Sensing for Archaeology, Research and Conservation (AARG 2011)*. Institute of Prehistory, Adam Mickiewicz University, Poznań, Poland, p. 16.

Doneus M., Neubauer W., Verhoeven G., Briese C. 2011. Advancing Archaeological Airborne Remote Sensing. Core Concepts of the LBI-ArchPro Initiative. In: Drahor, M. G., Berge M.A.: *Archaeological Prospection*. 9<sup>th</sup>

International Conference on Archaeological Prospection. September 19-24, 2011 Izmir-Turkey, Archaeology and Art Publications, Istanbul 2011, 12-15.

Doneus M., Griebel M. (Eds.) (in Press). Die Leitha - Facetten einer Landschaft. AÖ Spezial 3.

Doneus M., Verhoeven G., Fera M., Briese C., Kucera M., Neubauer W. 2011. From deposit to point cloud – a study of low-cost computer vision approaches for the straightforward documentation of archaeological excavations. Proceedings of the XXIIIrd International CIPA Symposium, Prague, Czech Republic, September 12 - 16, 2011.

Doneus N. (in Press). Roman rural landscape in west Pannonia: A Case Study of the Roman Site at Halbturn, Austria (2nd - 5th centuries AD). Spatial Analysis Applied to Archaeological Sites from Protohistory to the Roman Period, Sidestone Press.

Gugl Ch., Doneus M. 2011. Zur Wasserversorgung der Zivilstadt von Carnuntum. In: Humer F., Konecny A. (Hrg.) Römische Thermen – Forschung und Präsentation. Akten des internationalen Kolloquiums, veranstaltet vom Archäologischen Park Carnuntum und der Gesellschaft der Freunde Carnuntums 17.-18. September 2009, 107-120.

Gugl Ch., Doneus M., Humer F., Klein M., Paschke V., Weinlinger G. 2011. Aus alten Ruinen wiedererstanden. In: Bruckmüller, Ernst; Humer, Franz (Hrg.): Erobern - Entdecken - Erleben im Römerland Carnuntum, Katalog zur Niederösterreichischen Landesausstellung 2011 ; 16. April - 15. November. 58-69.

Mehofer M., Kucera M. 2011. Spurensuche im Detail. Linearbandkeramisch und frühbronzezeitlich datierte Keramikfragmente aus Hainburg/Teichtal – Archäometrische Untersuchungen. Archäologie Österreichs, 22-1, 51-53.

Sailer R., Bollmann E., Briese C., Fischer A., Klug C., Krainer K., Pfeifer N., Schümberg M., Stötter J. 2011. "The quantification of changes in the alpine cryosphere and periglacial environment based on ALS data"; Talk: Managing Alpine Future II, Innsbruck.

Schreg R., Kastowsky-Priglinger K., Trinks I. 2011. Großflächige archäologische Landschaftsprospektion auf der Stubersheimer Alb. Archäologische Ausgrabungen in Baden-Württemberg 2011, 39-44.

Trinks I., Biwall A., Lightning-induced Remanent Magnetisation as Plausible Explanation for a Geophysical Anomaly at Gråborg, Fornvänner, 2011, 350-354.

Verhoeven G. 2011. Mapping by matching - A computer vision-based approach to fast and accurate georeferencing of archaeological aerial photographs. In: Ambitions and Realities. Remote Sensing for Archaeology, Research and Conservation (AARG 2011). Institute of Prehistory, Adam Mickiewicz University, Poznań, Poland, 18-19.

Verhoeven G., Doneus M., Briese C. 2011. Towards Archaeologically Relevant Hyperspectral Sampling. In: 31st EARSeL Symposium. Remote Sensing and Geoinformation not only for Scientific Cooperation. Prague, Czech Republic, 30 May-2 June 2011 Symposium Program and Abstract Book, 16.